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Port of Seattle

East Waterway Operable Unit Quality Assurance Project Plan Sediment Transport Characterization

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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Prepared by

ANCHOR QEA
1423 3rd Avenue • Suite 300
Seattle, Washington • 98101

and

Battelle
Seattle Research Center
1100 Dexter Avenue N. • Suite 400
Seattle, WA • 98109

EAST WATERWAY SEDIMENT TRANSPORT CHARACTERIZATION QUALITY ASSURANCE PROJECT PLAN

APPROVALS

Anchor QEA Project Manager: ________ Name ________ 4/13/09 Date

Anchor QEA QA/QC Manager: ________ Name ________ 4/14/09 Date

EPA Project Manager: ________ Name ________ 5/19/09 Date

EPA QA Officer: ________ Name ________ 5/11/09 Date

for Ginna Grepo-Grove

DISTRIBUTION LIST

This list identifies all individuals who will receive a copy of the approved Sediment Transport Characterization Quality Assurance Project Plan, either in hard copy or electronic format, as well as any subsequent revisions:

- Ravi Sanga, EPA Project Manager
- Kym Takasaki, Environmental Scientist, USACE
- Joe Gailani, Research Hydraulic Engineer, USACE
- Earl Hayter, Research Hydraulic Engineer, USACE
- Tom Wang, Anchor QEA Project Manager
- Kathy Ketteridge, Anchor QEA Task Manager
- David Gillingham, Anchor QEA Field Coordinator
- Delaney Peterson, Anchor QEA QA/QC Manager

Chemistry Project Managers:

- Sue Dunnihoo (Analytical Resources, Inc.)
- Hewitt Jeter (Mass Spec Services)
- Craig Jones (Sea Engineering, Inc.)

East Waterway Group:

- Doug Hotchkiss, Port of Seattle
- Debra Williston, King County
- Jeff Stern, King County
- Peter Rude, City of Seattle

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%R	percent recovery
ADCP	Acoustic Doppler Current Profiler
Anchor QEA	Anchor QEA, LLC
ARI	Analytical Resources, Inc.
ASAOC	Administrative Settlement Agreement and Order on Consent
ASTM	American Society for Testing and Materials
Be-7	Beryllium-7
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
COC	chain-of-custody
Cs-137	Cesium-137
CSM	Conceptual Site Model
CSO	combined sewer outfall
CTD	conductivity temperature depth
DQIs	data quality indicators
DQOs	data quality objectives
EE/CA	Engineering Evaluation/Cost Analysis
EISR	Existing Information Summary Report
EPA	U.S. Environmental Protection Agency
EW	East Waterway
EWG	East Waterway Group
FC	Field Coordinator
GC/MS	gas chromatograph/mass spectrometer
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high density polyethylene
Hz	hertz
ID	identification
LDI	Laboratory Data Consultants, Inc.
LDW	Lower Duwamish Waterway
MDL	method detection limit
MHHW	mean higher high water
MHW	mean high water

MLLW	mean lower low water
MLW	mean low water
mm	millimeters
MNR	monitored natural recovery
MS/MSD	matrix spike/matrix spike duplicate
MTL	mean tide level
NAD	North American Datum
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Act
OU	Operable Unit
Pb-210	Lead-210
PM	Project Manager
PQLs	practical quantitation limits
PSEP	Puget Sound Estuary Program
PTM	particle tracking model
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
Rn-222	Radon-222
RPD	relative percent difference
SCE	Source Control Evaluation
SCEAM	Source Control Evaluation Approach Memorandum
SDG	sample delivery group
SEDGM	Initial Source Evaluation and Data Gaps Memorandum
SEI	Sea Engineering, Inc.
SOP	standard operating procedure
SOW	Statement of Work
SRI	Supplemental Remedial Investigation
SRI/FS	Supplemental Remedial Investigation/Feasibility Study
STC	Sediment Transport Characterization
STE	Sediment Transport Evaluation

STEAM	Sediment Transport Evaluation Approach Memorandum
TM	Task Manager
TOC	total organic carbon
TSS	total suspended solids
U-238	Uranium-238
U&A	Usual and Accustomed
USACE	U.S. Army Corps of Engineers
WW	West Waterway

1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) for Sediment Transport Characterization (STC) has been prepared as part of the Supplemental Remedial Investigation/Feasibility Study (SRI/FS) for the East Waterway (EW) Operable Unit (OU) of the Harbor Island Superfund Site as ordered by the U.S. Environmental Protection Agency (EPA) per the process defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or Superfund.

This QAPP is a required deliverable set forth in Section 3.7.4 of the SRI/FS Workplan for the EW OU (Anchor and Windward 2007), prepared in response to the Administrative Settlement Agreement and Order on Consent (ASAOC) and Statement of Work (SOW) (EPA 2006).

This QAPP describes the quality assurance (QA) objectives, methods, and procedures for collecting and analyzing data that will be utilized in the Sediment Transport Evaluation (STE) to characterize and evaluate sediment transport in the EW SRI study area. An overview of the STE approach is provided in the Sediment Transport Evaluation Approach Memorandum (STEAM; Anchor and Battelle 2008a) and is described in more detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b).

1.1 Project Overview

This section presents a general overview of the EW physical site characteristics pertinent to development of the STC QAPP. Additional detailed information on the environmental setting of the EW is presented in Section 2 of the Existing Information Summary Report (EISR; Anchor and Windward 2008a). This information includes habitat and biological conditions (EISR Section 2.3) and human use characteristics (EISR Section 2.4). Section 1 of the EISR also presents a detailed site history of the EW and surrounding areas.

The EW is located approximately 1 mile southwest of downtown Seattle, in King County, Washington. It is part of the greater Duwamish River estuary, which includes the freshwater/salt water interface extending as far as 10 miles upstream. At the southern end of Harbor Island, the river splits into the EW and the West Waterway (WW). From there, the EW and the WW extend to Elliott Bay at the north end of Harbor Island. The EW runs along the entire eastern shore of Harbor Island (Map 1-1). The Lower Duwamish Waterway

(LDW) Superfund Site is located immediately upstream of the EW (i.e., upstream of Harbor Island).

The EW is approximately 7,600 feet long, and for most of its length is 750 feet wide. It is channelized and has a south-to-north orientation. Four bridges cross over the EW along the Spokane Street corridor, located approximately at Station 6850 (Map 3-2). The Spokane Street corridor includes three lower bridges and one high bridge (West Seattle Bridge). The lower bridges include (from north to south) the Spokane Street Bridge (which includes a fishing pier bridge along the north side), the Railroad Bridge, and the Service Road Bridge. Immediately north of the Service Road Bridge, the EW is approximately 250 feet wide. It narrows to approximately 150 feet wide south of the Service Road Bridge (Map 1-1).

Existing bathymetry varies from approximately -40 to -60 feet mean lower low water (MLLW) (near the mouth) in the 750-foot-wide portion of the EW (DEA 2003). Mudline elevations rise to between -13 and -6 feet MLLW in the vicinity of the Spokane Street corridor (DEA 2003). However, besides limited water depth sounding in the EW south of the Spokane Street corridor (NOAA 2004), no detailed bathymetry exists in the vicinity of the Spokane Street corridor and south of the Spokane Street corridor. The shallow water depths associated with this "sill" along the Spokane Street corridor form a physical constriction across the entry to the EW that causes the Duwamish River to primarily flow through the WW. The presence of the bridges along the Spokane Street corridor also prohibits any type of boat passage, except at low tide by small, shallow-draft boats (e.g., kayaks and skiffs).

South of the Spokane Street corridor, the EW consists of riprap banks extending to the southern tip of Harbor Island. The shoreline within the EW is highly developed and primarily composed of piers, riprap, constructed seawalls, and bulkheads constructed for industrial and commercial use. In addition, three combined sewer outfalls (CSOs) and 39 storm drains are present along the EW that contribute freshwater and solids to the waterway.

The EW north of the Spokane Street corridor experiences regular vessel traffic of various sizes and types, including significant tug and barge traffic. Container ships call at Terminals

18 (T-18), 25 (T-25), and 30 (T-30). Cruise ships previously called at T-30 for several years; however, they are moving to Pier 91 in 2009 and T-30 will again be utilized as a container terminal. U.S. Coast Guard vessels home port at the U.S. Coast Guard Station at Pier 36. The EW is used for Tribal Usual and Accustomed (U&A) fishing. A public fishing pier is present along the north side of the Spokane Street Bridge. South of the Spokane Street corridor, the Harbor Island Marina is located on the southern tip of Harbor Island and is used by recreational and commercial boats. Also present south of the Spokane Street corridor, a 750-foot dock along Harbor Island is used for commercial moorage.

1.2 Proposed Study Area Boundaries

The proposed study area boundaries for the EW SRI/FS were described in the EISR (Anchor and Windward 2008a) and are shown on Map 1-1. The proposed southern study area boundary of the EW is identical to the northern study area boundary of the LDW Superfund Site. The proposed northern study area boundary of the EW that was used in the 2003 Phase 1 Remedial Action Engineering Evaluation/Cost Analysis (EE/CA; Windward 2003) is shown on Map 1-1. The current proposed northern EW OU study area boundary is also shown on Map 1-1.

1.3 Document Organization

EPA guidance for QAPPs (EPA 2002) was followed in preparing this document. This section provides a summary of the information contained in each section of the QAPP. Subsequent sections are organized as follows:

- **Section 2:** Project Management
- **Section 3:** Data Generation and Acquisition
- **Section 4:** Assessments and Response Actions
- **Section 5:** Data Validation and Usability
- **Section 6:** References

2 PROJECT MANAGEMENT

2.1 Project/Task Organization

An overview of the project organization and the key personnel assigned as task leaders for the various tasks required for the STC (data collection and analyses) are shown schematically in Figure 2-1.

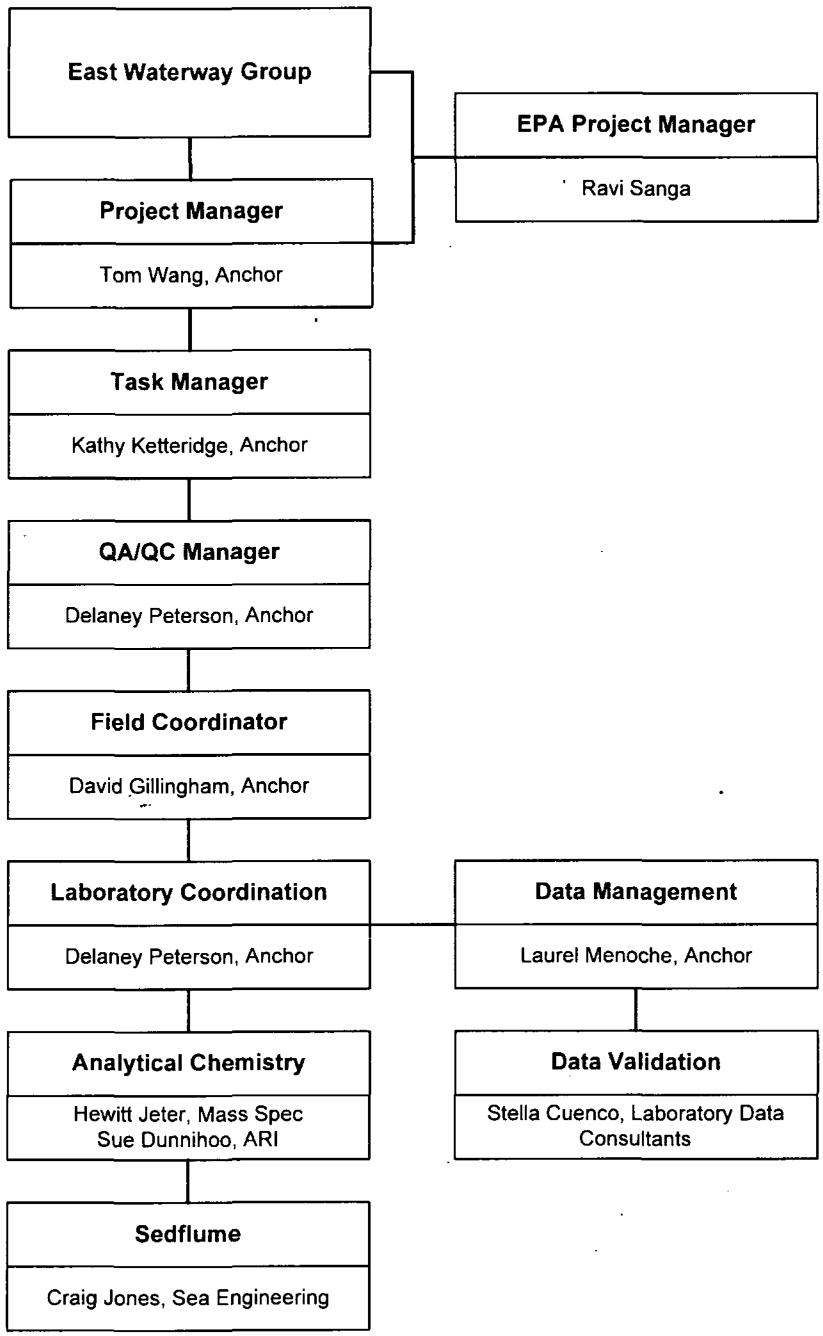

Figure 2-1 STC Project Management Organizational Chart

2.1.1 Project Management

EPA will be represented by its Project Manager (PM), Ravi Sanga. Mr. Sanga can be reached as follows:

Mr. Ravi Sanga
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
M/S ECL-115
Seattle, WA 98101-3140
Telephone: 206.553.4092
Facsimile: 206.553.0124
E-mail: Sanga.Ravi@epamail.epa.gov

Tom Wang, P.E., will serve as the Anchor QEA, LLC (Anchor QEA) PM and will be responsible for overall project coordination and providing oversight on planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. He will also be responsible for coordinating with the East Waterway Group (EWG) and EPA on schedule, deliverables, and other administrative details. Mr. Wang can be reached as follows:

Mr. Tom Wang, P.E.
Anchor QEA, LLC
1423 Third Avenue, Suite 300
Seattle, WA 98101
Telephone: 206.287.9130
Facsimile: 206.287.9131
E-mail: twang@anchorqea.com

Dr. Kathy Ketteridge, P.E., will serve as the Anchor QEA Task Manager (TM). The TM is responsible for project planning and coordination, production of work plans, production of project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. The TM is responsible for communicating with the Anchor QEA PM on progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to EWG and EPA. Dr. Ketteridge can be reached as follows:

Kathy Ketteridge, Ph.D., P.E.
Anchor QEA, LLC
1605 Cornwall Street
Bellingham, WA 98225
Telephone: 360.733.4311
Facsimile: 360.733.4312
E-mail: kketteridge@anchorqea.com

2.1.2 Field Coordination

David Gillingham will serve as the Anchor QEA Field Coordinator (FC). The FC is responsible for managing the field sampling activities and general field and quality assurance/quality control (QA/QC) oversight. He will ensure that appropriate protocols for sample collection, preservation, and holding times are observed and will oversee delivery of environmental samples to the designated laboratories for chemical analysis. Deviations from this QAPP will be reported to the Anchor QEA TM and PM for consultation. Significant deviations from the QAPP will be further reported to representatives of EWG and EPA. Mr. Gillingham can be reached as follows:

David Gillingham
Anchor QEA, LLC
1423 Third Avenue, Suite 300
Seattle, WA 98101
Telephone: 206.287.9130
Facsimile: 206.287.9131
E-mail: dgillingham@anchorqea.com

2.1.3 Quality Assurance/Quality Control

Delaney Peterson of Anchor QEA will oversee QA/QC for the project. As the QA/QC Manager, she will oversee coordination of the field sampling and laboratory programs and supervise data validation and project QA coordination. Ms. Peterson can be reached as follows:

Delaney Peterson
Anchor QEA, LLC
1423 Third Avenue, Suite 300
Seattle, WA 98101
Telephone: 206.287.9130
Facsimile: 206.287.9131
E-mail: dpeterson@anchorqea.com

Laboratory Data Consultants, Inc. (LDC) will provide independent third-party review and validation of analytical chemistry data. Stella Cuenco will act as the Data Validation PM and can be reached as follows:

Stella Cuenco
Laboratory Data Consultants, Inc.
7750 El Camino Real, Suite 2L
Carlsbad, CA 92009
Telephone: 760.634.0437
Facsimile: 760.634.0439
E-mail: scuenco@lab-data.com

2.1.4 Laboratory Project Management

Delaney Peterson of Anchor QEA will serve as the Laboratory Coordinator for the analytical chemistry and Sedflume laboratories (see contact information in Section 2.1.3). Mass Spec Services will perform the Cesium-137 (Cs-137), Lead-210 (Pb-210), and Beryllium-7 (Be-7) analyses of the sediment cores. Hewitt Jeter will serve as the Laboratory PM for Mass Spec Services. Analytical Resources, Inc. (ARI) will perform chemical and physical analyses. Sue Dunnihoo will serve as the Laboratory PM for ARI. Sea Engineering, Inc. (SEI) will perform the Sedflume analyses. Craig Jones will serve as the Laboratory PM for SEI. The Laboratory PMs can be reached as follows:

Hewitt Jeter
Mass Spec Services
(b) (6) [redacted]
Orangeburg, NY 10962
Telephone: (b) (6) [redacted]

Email: (b) (6) [redacted]

Ms. Susan Dunnihoo
Analytical Resources, Inc.
4611 S 134th Place, Suite 100
Tukwila, WA 98168
Telephone: 206.695.6207
E-mail: sue@arilabs.com

Craig Jones, Ph.D.
Sea Engineering, Inc.
200 Washington Street, Suite 210
Santa Cruz, CA 95060
Telephone: 831.421.0871
E-mail: craig.jones@sbcglobal.net

The laboratories will do the following:

- Adhere to the methods outlined in this QAPP, including those methods referenced for each procedure
- Adhere to documentation, custody, and sample logbook procedures
- Implement QA/QC procedures defined in this QAPP
- Meet all reporting requirements
- Deliver electronic data files as specified in this QAPP
- Meet turnaround times for deliverables as described in this QAPP
- Allow EPA and the QA/QC Manager, or a representative, to perform laboratory and data audits

2.1.5 Data Management

Laurel Menoche of Anchor QEA will oversee data management to ensure that analytical data are incorporated into the EW database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in the EW SRI/FS.

2.2 Problem Definition/Background

The SRI/FS Workplan (Anchor and Windward 2007) provides the guidelines and objectives for conducting the STE. These objectives were modified and refined during a workshop meeting between EWG and EPA representatives on August 18, 2008. The outcome of the meeting is documented and summarized in a technical memorandum from the consultant group to EPA dated November 11, 2008 (Anchor and Battelle 2008b). Because the EW receives flows from the LDW, and the proposed southern study area boundary of the EW OU is identical to the northern boundary of the LDW Superfund Site at the EW, the STE will be similar to the approach used to evaluate the sediment transport potential in the LDW conducted as part of the LDW RI/FS evaluation (Windward and QEA 2008; QEA 2007). The hydrodynamic model used for the LDW sediment transport analysis includes the EW as part of its model grid. However, as described in the STE Workshop Summary Memorandum, the bathymetry and grid resolution will be updated for the EW and the hydrodynamic model will be calibrated to the newly collected velocity data from the EW.

The objectives of the STE are as follows:

1. Identify and evaluate the primary sources of sediment to the EW
2. Identify spatial patterns of net sediment deposition
3. Identify the physical processes driving sediment transport
4. Identify likely routes or pathways for sediment movement
5. Assess how sediment transport pathways may affect the feasibility of remedial alternatives, including monitored natural recovery (MNR), enhanced natural recovery, dredging, and isolation capping
6. Assess the potential for physical processes to contribute to recontamination

The STE will include data collection, estimation of net sedimentation rate and erosion potential for the EW based on core data, hydrodynamic modeling, estimation of the erosion potential from natural process, estimation of the erosion potential and depth of erosion based on propeller wash (propwash) analyses, and localized particle tracking modeling to assess recontamination potential in the EW from lateral sources. A full-scale sediment transport model of the EW will not be performed.

The STE will be conducted using information described in the EISR (Anchor and Windward 2008a) and new information obtained through the STC sampling program described in this document. The results of the STE will be summarized in a Sediment Transport Evaluation Report, as described in the Workplan (Anchor and Windward 2007), and will be used to refine the Physical Processes Conceptual Site Model (CSM) presented in the CSM and Data Gaps Analysis Report (Anchor, Windward and Battelle 2008). The Physical Processes CSM will be refined in the Supplemental Remediation Investigation (SRI) Report.

2.3 Project/Task Description and Schedule

The STE approach described briefly in this section, and in more detail in Section 3.1, is a combination of data collection and hydrodynamic modeling analyses that will be used to validate or refine the Physical Processes CSM. The primary objectives of the STC sampling described in this QAPP are to provide data needed for evaluation of net sedimentation rate and erosion potential from natural processes and data required for updating and calibration of the existing LDW hydrodynamic model for application in the EW. Tasks that will be carried out to meet these objectives are as follows:

- Task 1: Evaluate net sedimentation in the EW (geochronological cores)
- Task 2: Analyze the critical shear stress of the bed sediment as a function of sediment characteristics and subsurface elevation (Sedflume cores)
- Task 3: Velocity, salinity, temperature, and bathymetry data collection in support of hydrodynamic modeling
- Task 4: Results Memoranda

Tasks 1 through 3 include the data collection efforts prescribed in this document. Task 3 data collection efforts are designed to support updating, calibrating, and running the existing LDW hydrodynamic model with improved resolution in the EW and potentially the confluence of the EW and LDW. There are no data collection efforts anticipated for the propeller wash modeling at this time; however, following the initial propwash analysis, additional data may be requested by EPA. Additional data needs would be described in another QAPP.

The data collected in Tasks 1 through 3 will be summarized in a series of Results Memoranda (Task 4), which will be parsed out as data become available. A milestone decision point will be reached following completion of the STC Tasks 1 through 4 above, which will include review by EPA and EWG of the Results Memoranda, as well as review of preliminary hydrodynamic modeling once completed. The decision point will address the following questions:

- Are the data collected in Tasks 1 through 3 adequate to meet the overall objectives of the STE? If the answer is no, additional data collection may be required. These data collection efforts may include, but are not limited to, incoming (LDW) total suspended solids (TSS) data, flocculent settling, and plume tracking.
- Based on this review, should the STE be modified?

If additional data are requested at that time, a separate QAPP will be provided for that sampling effort. Since specific data needs cannot be specified at this time, no tasks have been defined for those efforts in this document. Documentation of any refinement to the Physical Processes CSM will be provided in the SRI Report. Table 2-1 provides an outline of the anticipated schedule for completion of Tasks 1 through 4.

Table 2-1
Anticipated Project Schedule

Task	Subtask	Start Date	Completion Date
Task 1: Evaluate net sedimentation rate	Geochronology field work	04/09	04/09
	Geochronology laboratory analyses	04/09	06/09
Task 2: Analyze critical bed shear stress	Sedflume field work	05/09	05/09
	Sedflume laboratory analyses	05/09	06/09
Task 3: Velocity, salinity, temperature, and bathymetry data collection	Velocity profiles	03/09	07/09[a]
	Velocity transects and salinity profiles	05/09	05/09[b]
	Targeted bathymetry data collection	03/09	03/09
Task 4: Results Memoranda	EPA	04/09	06/09

Notes:

a Velocity profiles will be taken continuously for a period of 3 months

b Velocity transects and conductivity temperature depth (CTD) profiles will be collected over a single tidal cycle at some point within the sampling period for the velocity profiles

2.4 Data Quality Objectives and Criteria

The overall data quality objectives (DQOs) for this project are to ensure that the data collected are of known and acceptable quality so that the project objectives described in the

SRI/FS Workplan (Anchor and Windward 2007) can be achieved. Parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. These parameters are discussed and specific data quality indicators (DQIs) for laboratory analyses are presented in Section 3.4.2.

2.5 Special Training Requirements/Certifications

For sample preparation tasks, it is important that field crews are trained in standardized data collection requirements, so that the data collected are consistent among the field crews. All field crews are fully trained in the collection and processing of subsurface and Sedflume cores, velocity and salinity measurements, decontamination protocols, visual inspections, and chain-of-custody (COC) procedures.

In addition, the 29 CFR 1910.120 Occupational Safety and Health Act (OSHA) regulations require training to provide employees with the knowledge and skills enabling them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training course and 8-hour refresher courses, as necessary, to meet the OSHA regulations.

2.6 Documentation and Records

This project will require central project files to be maintained at Anchor QEA. Project records will be stored and maintained in a secure manner. Each project team member is responsible for filing all necessary project information or providing it to the person responsible for the filing system. Individual team members may maintain files for individual tasks, but must provide such files to the central project files upon completion of each task. A project-specific index of file contents is to be kept with the project files. Hard copy documents will be kept on file at Anchor QEA or at a document storage facility (e.g., Iron Mountain) throughout the duration of the project, and all electronic data will be maintained in the database at Anchor QEA.

2.6.1 Field Records

All documents generated during the field effort are controlled documents that become part of the project file.

2.6.1.1 Field Logs

Field team members will keep a daily record of significant events, observations, and measurements in a field log. All field activities will be recorded in a bound, paginated field logbook maintained by the FC or his designee for each activity. Field logbooks will be the main source of field documentation for all field activities. The on-site field representative will record in the field logbook information pertinent to the investigation program. The sampling documentation will contain information on each sample collected, and will include at a minimum the following information:

- Project name
- Field personnel on site
- Facility visitors
- Weather conditions
- Field observations
- Maps and/or drawings
- Date and time sample collected
- Sampling method and description of activities
- Identification or serial numbers of instruments or equipment used
- Deviations from the QAPP
- Conferences associated with field sampling activities

Entries for each day will begin on a new page. The person recording information must enter the date and time and initial each entry. In general, sufficient information will be recorded during sampling so that reconstruction of the event can occur without relying on the memory of the field personnel.

The field logbooks will be permanently bound and durable for adverse field conditions. All pages will be numbered consecutively. All pages will remain intact, and no page will be removed for any reason. Notes will be taken in indelible, waterproof blue or black ink. Errors will be corrected by crossing out with a single line, dating, and initialing. The front and inside of each field logbook will be marked with the project name, number, and logbook number. The field logbooks will be stored in the project files when not in use and upon completion of each sampling event.

Sample collection checklists will be prepared prior to each sampling program. The checklist will include location designations, types of samples to be collected, and whether any QC samples are to be collected.

2.6.2 Analytical Records

Analytical data records will be retained by the laboratory and in the Anchor QEA central project files. For all analyses, the data reporting requirements will include those items necessary to complete data validation, including copies of all raw data. The analytical laboratory will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as appropriate.
- **Chain-of-Custody Records.** Legible copies of the COC forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.
- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:
  - Field sample identification code and the corresponding laboratory identification code
  - Sample matrix
  - Date of sample extraction
  - Date and time of analysis
  - Weight and/or volume used for analysis
  - Final dilution volumes or concentration factor for the sample
  - Identification of the instrument used for analysis

- Method detection limits (MDLs)
- Method reporting limits (RLs) accounting for sample-specific factors (e.g., dilution, total solids)
- Analytical results with reporting units identified
- Data qualifiers and their definitions
- A computer disk with the data in a format specified in advance by Anchor QEA

- **QA/QC Summaries.** This section will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
- **Calibration Data Summary.** This summary will report the concentrations of the initial calibration and daily calibration standards, and the date and time of analysis. The response factor, percent relative standard deviation, percent difference, and retention time for each analyte will be listed, as appropriate. Results for standards to indicate instrument sensitivity will be documented.
- **Internal Standard Area Summary.** The stability of internal standard areas will be reported.
- **Method Blank Analysis.** The method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks will be reported.
- **Surrogate Spike Recovery.** This will include all surrogate spike recovery data for organic compounds. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed.
- **Matrix Spike Recovery.** This will report all matrix spike recovery data for organic and metal compounds. The name and concentration of all compounds added, percent recoveries, and range of recoveries will be listed. The relative percent difference (RPD) for all duplicate analyses will be included.
- **Matrix Duplicate.** This will include the percent recovery (%R) and associated RPD for all matrix duplicate analyses.
- **Laboratory Control Sample.** All laboratory control sample recovery data for organic and metal compounds will be reported. The name and concentration of

all compounds added, %R, and range of recoveries will be listed. The RPD for all duplicate analyses will be included.

- **Relative Retention Time.** This will include a report of the relative retention time of each analyte detected in the samples for both primary and conformational analyses.
- **Original Data.** Legible copies of the original data generated by the laboratory will include:
  - Sample extraction, preparation, identification of extraction method used, and cleanup logs
  - Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
  - Calculation worksheets for inorganic analyses
  - Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials
  - Original printouts of full scan chromatograms and quantitation reports for all gas chromatograph (GC) and/or gas chromatograph/mass spectrometer (GC/MS) samples, standards, blanks, calibrations, spikes, replicates, and reference materials
  - Enhanced spectra of detected compounds with associated best-match spectra for each sample

All instrument data shall be fully restorable at the laboratory from electronic backup. Laboratories will be required to maintain all records relevant to project analyses for a minimum of 7 years. Data validation reports will be maintained in the central project files with the analytical data reports.

2.6.3 Data Reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the Laboratory Manager, the PM, the QA/QC Manager, and independent reviewers. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

2.6.4 Results Memoranda

Anchor QEA will prepare a series of Results Memoranda that will include data summaries for geochronological cores (Task 1); Sedflume analyses (Task 2); and velocity, salinity, temperature, and bathymetry data (Task 3) provided to EPA as the data become available. These memoranda will include raw data for each of those tasks. Interpretation of the data and results of the STE will be presented in the Sediment Transport Evaluation Report.

At a minimum, the following will be included in the Results Memoranda:

- Summary of all field activities, including descriptions of any deviations from the approved QAPP
- Sampling locations reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- Plan view of the study area showing the actual sampling locations
- Summary of the QA/QC review of the physical and chemical data
- Copies of field logs (appendix)
- Copies of COC forms (appendix)
- Data validation report (appendix)
- Results from the analyses of field samples, both as summary tables in the main body of the report, and appendices with data forms submitted by the laboratories and as cross-tab tables produced from Anchor QEA's database
- Contour map of additional bathymetry in the Sill Reach
- Summary time-series plots of Acoustic Doppler Current Profiler (ADCP) profile (moored instrument) data and transect (towed instrument) data
- Summary plots of vertical variation in salinity and temperature from the conductivity temperature depth (CTD) casts

Chemical and physical data will be validated within 4 weeks of receiving data packages from the respective laboratories. A draft Results Memorandum will be submitted to

EPA 4 weeks after receipt of the validated analytical results. A final Results Memorandum will be submitted to EPA 3 weeks after receiving comments on the draft.

3 DATA GENERATION AND ACQUISITION

This section documents the study design and methods that will be used for the STC in the EW, including the methods to collect, process, and analyze sediment samples (chemically and physically) collected from the EW. Elements include sampling design, locations, and methods; sample handling and custody requirements; analytical chemistry methods; QA/QC; instrument and equipment testing, inspection, maintenance, and calibration; supply inspection and acceptance; non-direct measurements; and data management.

3.1 Sampling Design

This section describes the particular elements of the STE that will be supported by the proposed sampling program, which is referred to in this document as the Sediment Transport Characterization (STC). The proposed methodology for the STE is documented in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). A brief summary of the tasks to be completed during the STE are listed below:

1. Evaluation of Hydrodynamics within the EW: The existing LDW hydrodynamic model (Windward and QEA 2008; QEA 2007) will be updated and calibrated to resolve hydrodynamics within the EW study area. The model will provide horizontal and vertical velocities throughout the water column and be used to evaluate erosion potential.
2. Evaluation of Sediment Transport by Natural Processes: MNR and recontamination analyses will use the net sedimentation rates estimated from the empirical site-specific data collected during the STC. The erosion potential within the EW study area will be evaluated based on empirical site-specific measurements of critical bed shear stress and erosion rate from Sedflume cores and hydrodynamic modeling.
3. Evaluation of Sediment Transport from Lateral Loads: The Source Control Evaluation Approach Memorandum (SCEAM; Anchor and Windward 2008b) describes how potential sources of sediment recontamination are to be evaluated. The Source Control Evaluation (SCE) for sediment (solids) and flow input to the EW is available in the draft Initial Source Evaluation and Data Gaps Memorandum (SEDGM; Anchor and Windward 2008c). The results of ongoing efforts to evaluate chemistry for lateral loads will be documented in the SRI Report. Sediment loads and flows for lateral sources, along with the results from the hydrodynamic model, will be used in the STE as input to the localized lagrangian particle tracking model (PTM). PTM will be used to evaluate

the fate and transport within the EW study area of sediment entering the EW through lateral sources.

4. Evaluation of Erosion Potential from Propwash: Propwash modeling (JETWASH and VHPU models) will be completed over a range of vessel sizes and operating condition scenarios. The results of the modeling, along with the critical shear stress values devloped from Sedflume cores, will be used to develop a map indicating where propwash has the potential to erode the existing sediment bed (along with identifying the spatial extent and depth of erosion and the critical vessel/scenario).

The primary objective of the STE is to improve and refine the Physical Processes CSM (Anchor, Windward and Battelle 2008) for evaluation of sediment transport within the EW study area. Therefore, the study design of the STC is based on a weight-of-evidence approach to assess the validity of the preliminary Physical Processes CSM for sediment transport in the EW. The project is focused on the preliminary Physical Processes CSM, which will be tested and refined as necessary, with the ultimate goal being development of the Physical Processes CSM for sediment transport that supports future remedial design activities. The Physical Processes CSM will be refined in the SRI Report. The results of the STC will be used to complete the STE, which will be documented in the Sediment Transport Evaluation Report. Work conducted for the STC, and outlined in this QAPP, will consist of four primary tasks, listed in Section 2.3 and described in detail in Sections 3.1.1 through 3.1.4.

3.1.1 Evaluation of EW Depositional Environment (Task 1)

The primary objective of this task is to provide empirical estimates of net sedimentation within the entire EW study area, which along with data collected in Tasks 2 and 3, will be utilized in the STE to evaluate the Physical Processes CSM. The current understanding of sediment transport within the EW study area is discussed in detail in Sections 2.1.2 and 2.1.3 of the CSM (Anchor, Windward and Battelle 2008). In general, the EW is considered to be net depositional with re-suspension potential due to flow events and tidal currents in the shallows and re-suspension potential due to propwash in the Main Body Reach. The majority of the sediment deposited within the EW is supplied through wash load from the LDW.

A full-scale sediment transport model of the EW will not be performed; therefore, net sedimentation within the EW will be estimated from an analysis of geochronological cores collected at a relatively high density from the EW within areas that have not been previously dredged since approximately 1964. The previously dredged locations were presented in Figures 3-3, 3-4, 4-4, and 4-5 in the EISR (Anchor and Windward 2008a), and these undredged locations are being used to guide the sampling locations of cores.

Existing sedimentation rate data for the EW are listed and evaluated in Sections 2.3 and 2.9 of the STEAM (Anchor and Battelle 2008a), and summarized in Table 3-3 of that document. Data gaps identified for these parameters are summarized in Table 3-4 of the STEAM and are discussed in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). The STC will collect data identified in the data gaps evaluation, with the exclusion of lateral solids loadings. Data gaps associated with lateral solids loadings are discussed in the SEDGM (Anchor and Windward 2008c) and will be addressed in additional field studies and documented in a separate QAPP.

The geochronology field study will obtain estimates of net sedimentation rate, grain size distribution, bulk density, percent solids, and total organic carbon (TOC) at each core location with the EW. A total of 22 geochronological cores are proposed.

3.1.1.1 Theoretical Basis

The radioisotopes Cs-137 and Pb-210 are used to age-date sediments and establish sedimentation rates in estuarine and freshwater systems (Olsen et al. 1978; Orson et al. 1990). Cs-137 concentrations in sediments are derived from atmospheric fallout from nuclear weapons testing. The first occurrence of Cs-137 in sediments generally marks the year 1954, while peak concentrations correspond to 1963 (Simpson et al. 1976). Based on these dates, long-term average sedimentation rates can be computed by dividing the depth of sediment between the sediment surface and the buried Cs-137 peak by the number of years between 1963 and the time of core collection (e.g., 41 years for a core collected in 2004). Sediment core dating using Cs-137 has been successfully accomplished in EW and WW sediment areas adjoining the LDW (EVS and Hart Crowser 1995). Pb-210, which is a decay product of volatilized atmospheric Radon-222 (Rn-222), is present in sediments primarily as a result of recent atmospheric deposition. Rn-222 is a volatile, short-lived intermediate daughter of Uranium-238 (U-238), a naturally occurring radioisotope found in the earth's crust. Long-term sedimentation rates can be estimated using Pb-210 sediment data because Pb-210 is deposited on the earth's surface at an approximately constant rate related to the volatilization rate of Rn-222 from the earth's surface, and the activity of Pb-210 in sediment decreases exponentially as a function of its decay half-life of 22.3 years. Thus, the long-term sedimentation rate can be estimated by analyzing the vertical profile of Pb-210 activity in a sediment core (Olsen et al. 1978; Orson et al. 1990; Robbins 1978). Sediment core dating using Pb-210 has been successfully accomplished in Puget Sound (Lavelle et al. 1985).

3.1.1.2 Sampling Locations

Several criteria were considered in the selection of the number and locations of sediment cores for this study:

- Samples should provide reasonable spatial coverage throughout the EW such that potential longitudinal variations in the depositional environment of the EW can be resolved
- Samples should be representative of the different hydrological regimes present within the EW
- Samples should be taken from areas which that have not been previously dredged since approximately 1964
- Samples should not be taken in areas that are anticipated to have experienced excessive erosion or continual mixing

Proposed core sampling locations are presented in Maps 3-1 and 3-2 and summarized in Table 3-1. Cores will be a maximum of 90 centimeters (cm) in length (or to refusal) and sliced into 2-cm sections. One 2-cm sample from each 6-cm increment will be tested and all others will be archived. Specific sampling methods are described in Section 3.2.3.

Table 3-1
Proposed Geochronological Cores

Core ID	EW Station	Easting[a]	Northing[a]	Elevation (ft MLLW)	Total Number of Samples	Number Analyzed
GC_1	-100	1267343	219174	-56	45	15
GC_2	0	1267891	218996	-42	45	15
GC_3	550	1267424	218519	-56	45	15
GC_4	1100	1267271	217940	-58	45	15
GC_5	1100	1267594	217953	-54	45	15
GC_6	1500	1267409	217524	-55	45	15
GC_7	2100	1267548	216964	-55	45	15
GC_8	2300	1267297	216726	-55	45	15
GC_9	3900	1267204	213790	-20	45	15
GC_10	4200	1267666	213803	-20	45	15
GC_11	5300	1267205	213790	-40	45	15
GC_12	5300	1267422	213797	-44	45	15
GC_13	5300	1267667	213803	-50	45	15
GC_14	6000	1267172	213064	-38	45	15
GC_15	6000	1267410	213056	-38	45	15
GC_16	6000	1267647	213051	-40	45	15
GC_17	6500	1267191	212587	-15	45	15
GC_18	6500	1267296	212565	-30	45	15
GC_19	6550	1267396	212537	-20	45	15
GC_20	6850	1267231	212246	None available	45	15
GC_21	7300	1267126	211751	None available	45	15
GC_22	7600	1267032	211459	None available	45	15
Equipment:	4-inch steel core tube					
Minimum target penetration:	78 cm (based on 2 cm/year sedimentation)					
Slice interval:	2 cm					
Analysis interval:	Every third slice					

Notes:

a Washington State Plane North, NAD83, feet

3.1.1.3 Data Analysis

For this study, average sedimentation rates will be calculated for interpretable cores[1]. This approach produces the best estimate of long-term average

1 Experience from geochronology studies at other sites shows that useful data and information are not typically extracted from every core. For example, an erratic depositional history at a particular location might produce complex Pb-210 or Cs-137 profiles that cannot be used to determine the average long-term sedimentation rate with

sedimentation rates. Through examination of vertical profiles of radioisotope concentrations in conjunction with stratigraphic and sediment bed property information, a description of the depositional environment at each core location will be developed.

Stratigraphic and sediment bed property data include general sediment type (via visual observation), approximate grain size (via visual observation), TOC content, bulk density, and total solids.

The results of the geochronology analyses, along with other relevant information, will be used to develop a weight-of-evidence characterization of the depositional environment in the EW. While estimates of sedimentation rates are a primary result of these analyses, other insights about the EW depositional environment may also result from this work. These insights may include, but are not limited to, potential temporal variations in deposition rates from propwash, and the extent to which episodic events (as evidenced by disturbances in the vertical profiles of Pb-210 and Cs-137) may have affected erosion and deposition in the EW.

3.1.2 Analyze Critical Bed Shear Stress (Task 2)

The primary goal of this task is to provide site-specific empirical measurements of the critical bed shear stress within the EW study area. As discussed in Section 3.1.1, a full-scale sediment transport model will not be utilized for the EW STE. However, an evaluation of erosion potential will be carried out using a combination of the predicted fluid shear stress at the bed determined through the hydrodynamic modeling (discussed in more detail in Section 3.1.3) and empirical estimates of the critical shear stress of the bottom sediments within the EW determined through the analysis of Sedflume cores.

There are no known site-specific measurements of critical bed shear stress within the EW study area. Discussion and evaluation of data availability and suitability are provided in the EISR (Anchor and Windward 2008a) and STEAM (Anchor and Battelle 2008a). Data gaps identified for these parameters are summarized in Table 3-4 of the

reasonable accuracy. In these cases, other data collected from these cores (e.g., TOC and bulk density) may still provide useful information for the STE.

STEAM and are discussed in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). The STC will obtain laboratory measurements of critical shear stress, sediment erosion rate as a function of subsurface depth, and applied shear stress above critical in the EW study area, as identified in the data gaps evaluation, through the use of Sedflume core data. Critical bed shear stress and grain size distribution as a function of subsurface depth will be measured at seven locations within the EW.

3.1.2.1 Theoretical Basis

Erosion rate data obtained from Sedflume testing are analyzed to develop an understanding of the erosion properties of Site sediments. The goal of this analysis is to develop a functional relationship between gross erosion rate (E_{gross}) and other parameters that affect erosion rate. It is assumed in this study that erosion rate is dependent on shear stress (Jones 2000):

$$E_{gross} = A\,\tau^n \quad \text{for } \tau > \tau_{cr}$$
$$= 0 \quad \text{for } \tau \leq \tau_{cr}$$

(Equation 3-1)

Where: E_{gross} is gross erosion rate (cm/s), τ is shear stress (Pa), and τ_{cr} is critical shear stress (Pa), which is the shear stress at which a small, but measurable, rate of erosion occurs. The erosion parameters, A and n, are site-specific and may be spatially variable, both horizontally and vertically.

The site-specific parameters, A and n, are determined using the erosion rate data collected during the Sedflume field study. Each core is divided into 5-cm-thick layers (i.e., 0-5, 5-10, 10-15, 15-20, and 20-25 cm depth intervals). These depth intervals are chosen because the shear stress series used in the Sedflume tests, where shear stress is increased from low to high values, are cycled over approximately 5-cm-thick layers. The erosion rate data within each layer of a particular core are analyzed through application of a log-linear regression analysis between erosion rate and shear stress. The log-linear regression analysis produces values of A and n (see Equation 3-1) for each 5-cm layer in a particular core.

The critical shear stress (τ_{cr}), defined as the shear stress at which a small but measurable rate of erosion is observed, is estimated from Sedflume erosion rate data. For Sedflume studies performed at other sites (Jones 2000; McNeil et al. 1996; Jepsen et al. 2001), the critical erosion rate was set at 10^{-4} cm/s, a value that consistently corresponds to initiation of erosion. Thus, a critical erosion rate of 10^{-4} cm/s is used in this study. The critical shear stress is calculated by rearranging Equation 3-1:

$$\tau_{cr} = (E_{gross}/A)^{1/n} \qquad \textbf{(Equation 3-2)}$$

Where: E_{gross} is equal to 10^{-4} cm/s.

Sedflume measures the gross erosion rate, which is a quantity that may be significantly larger than the net erosion rate. Calculation of net erosion rate using Sedflume data requires incorporation of the gross erosion data into a sophisticated sediment transport model. The proposed STE approach for the EW does not include sediment transport modeling. Therefore, the purpose of the Sedflume data is to obtain estimates of critical shear stress (τ_{cr}) as a function of bottom velocity and depth into the sediment bed. These will be compared with the fluid shear stress estimates at the sediment bed obtained from the hydrodynamic model. If the fluid shear stress exceeds the measured critical shear stress, then the sediment at that location will erode and MNR may not be a suitable option at that location.

3.1.2.2 Sampling Locations

Several criteria were considered in the selection of the number and locations of Sedflume cores for this study:

- Samples should be placed in suspected natural recover areas
- At least one sample should be placed at each of the boundaries of the study area (north and south boundaries)
- One sample should be placed in the Sill Reach (shallow water) in the vicinity of the bridges
- Samples should be located and spaced appropriately at the various constriction changes within the Sill and Junction Reaches of the EW to evaluate potential spatial variability of results in those areas

The proposed core sampling locations are presented in Maps 3-1 and 3-2 and summarized in Table 3-2.

Table 3-2
Proposed Sedflume Cores

Core ID	EW Station	Easting[a]	Northing[a]	Elevation (ft MLLW)[b]	Number of Cores
SF_1	6000	1,267,410	213,056	-38	1
SF_2	5300	1,267,422	213,796	-44	1
SF_3	6500	1,267,296	212,565	-30	1
SF_4	7100	1,267,159	212,015	None available	1
SF_5	6800	126,7231	212,246	None available	1
SF_6	7600	1,267,032	211,459	None available	1
SF_7	550	1,267,424	218,519	-56	1
Equipment:	10-cm by 15-cm rectangular tube				
Minimum target penetration:	30 cm				

Notes:

a Washington State Plane North, NAD83, feet

b Elevation is approximate. Estimated from current bathymetry data.

3.1.3 Velocity, Salinity, Temperature, and Bathymetry Data Collection (Task 3)

The primary goal of this task is to provide site-specific empirical measurements of velocity, salinity, and temperature, and additional bathymetry within the EW study area. These data will facilitate the updating and calibrating of the existing LDW hydrodynamic model for the EW. At present, the LDW model is not calibrated for the EW; the calibration was for the LDW itself and the WW. The current understanding of the hydrodynamics within the EW is discussed in detail in Section 2.1.1 of the CSM (Anchor, Windward and Battelle 2008). In order to validate the Physical Processes CSM for the EW, a hydrodynamic model will be utilized along with data collection to facilitate calibration of the model. The proposed data collection efforts for velocity, salinity, temperature, and bathymetry (described in detail in Sections 3.2.5 and 3.2.6) are targeted to allow examination of the proposed hydrodynamic characteristics of the EW study area and calibration of the hydrodynamic model.

3.1.3.1 Hydrodynamic Model

The hydrodynamic modeling study used to examine the sediment transport potential in the LDW was published in January 2008 (Windward and QEA 2008; QEA 2007). The hydrodynamic model developed for the LDW will be utilized for the EW efforts, with modifications to the EW bathymetry and grid structure within the EW and potentially within the confluence of the EW and the LDW. The hydrodynamic information from the model will be used to support analysis of erosion potential under high flow conditions and provide input to the PTM model for evaluation of lateral loads. The analysis of erosion potential will inform the feasibility of natural recovery processes, and potentially the need to remediate buried contamination.

An evaluation of the availability and suitability of the LDW hydrodynamic model is provided in the STEAM (Sections 2.4 and 2.9 and Table 3-3, Anchor and Battelle 2008a). The proposed modifications to the LDW model grid are provided in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). A summary of the proposed modifications to the resolution of the LDW model are provided below:

- In the Main Body Reach, use 9 grid cells across the EW.
- In the Sill Reach, use 3 calculation cells across the EW, expanding to 4 and 5 north of the bridges.
- Along the channel of the EW, calculation cells should be approximately 200 feet long (north to south). This will produce approximately 300 grid cells within the Main Body Reach of the EW (approximately 31 x 9 cell grid).
- In Slip 27, use a 3 x 3 grid.
- In Slip 36, use 3 cells across (north to south), with 4 cells deep (east to west).
- Additional increases to model resolution in the confluence of the EW and LDW may be required. It should be recognized that the number of grid cells listed in the bullets above is approximate, and that the final grid resolution will be based on the need for accurate hydrodynamic results.

Results of the hydrodynamic modeling effort for the EW, including calibration, will be provided in the Sediment Transport Evaluation Report.

3.1.3.2 Velocity

Available velocity data for the EW are documented and evaluated in the STEAM (Anchor and Battelle 2008a). Velocity data gaps are identified in Table 3-4 of the STEAM and are discussed in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). Velocity data will be collected to address the documented data needs for the STE. These measurements will include vertical profiles and transects of currents within the EW. An effort will be made to collect data at the boundaries of the EW study area and in the Sill and Junction Reaches where the velocity fields are anticipated to be the most complex. Velocity data will be utilized to calibrate the updated LDW model for evaluation of hydrodynamics in the EW.

3.1.3.3 Salinity and Temperature

There are limited site-specific empirical measurements of salinity or temperature profiles within the EW study area. King County has collected monthly salinity and temperature profiles in the EW at HNF/C1/C2 since February 2008 (10 profiles to date). Discussion and evaluation of data availability and suitability are provided in the STEAM (Anchor and Battelle 2008a). Data gaps identified for these parameters are summarized in Table 3-4 of the STEAM and are discussed in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). Salinity data will be collected to address the documented data needs for the STE. These measurements will include vertical profiles of salinity and temperature within the EW study area. An effort will be made to collect data at the boundaries of the EW study area. Salinity and temperature data will be utilized to calibrate the updated LDW model for evaluation of hydrodynamics in the EW.

3.1.3.4 Bathymetry

Available bathymetry data for the EW are documented and evaluated in the STEAM (Anchor and Battelle 2008a). Bathymetry data gaps are identified in Table 3-4 of the STEAM and are discussed in detail in the STE Workshop Summary Memorandum (Anchor and Battelle 2008b). Bathymetry will be collected only in areas where data are missing in the vicinity of the Sill Reach and along the piers where data gaps currently exist. The new bathymetry data will be combined with the existing bathymetry outlined in the STEAM to update the bathymetry of the existing LDW model for the evaluation of the hydrodynamics in the EW. Figure 2-4 in the STEAM illustrates the area in the vicinity of the Sill Reach where no bathymetry data presently exist. The approximate area where bathymetry data will be collected is between EW Stations 6800 and 7600 (see Map 1-1). If possible, additional bathymetry between EW Stations 6200 and 6800 will also be collected during this effort.

3.1.3.5 Sampling Locations

Selection criteria for the number and location of proposed velocity, salinity, and temperature measurements are summarized below:

- Provide velocity information with enough spatial and temporal resolution to allow calibration of the updated hydrodynamic model of the EW.
- Provide transects of towed velocity measurements that can be completed within 1 hour, maximum. This is to ensure that the dataset is synoptic in terms of tidal phase.
- Provide velocity information along the centerline of the EW channel, if possible.
- Provide salinity and temperature information with enough spatial and temporal resolution to allow calibration of the updated hydrodynamic model of the EW, and provide sufficient data to quantify the flow exchange between the LDW and the EW.

Map 3-3 illustrates the locations for the proposed velocity profiles, transects, and salinity profiles. Table 3-3 provides the locations of the velocity and salinity profiles and sampling parameters. Velocity transects include the centerline of the EW from Stations 0 to 6800, with lateral transects at Stations 6800, 6000, 3900, and 600.

Table 3-3
Proposed Velocity and Salinity Profiles

Profile ID	EW Station	Easting[a]	Northing[a]	Elevation (ft MLLW)[b]
ADCP_1_North (CTD_1)	850	1,267,403	218,237	-55
ADCP_2_Middle (CTD_2)	3950	1,267,475	215,103	-55
ADCP_3_South (CTD_3)	6750	1,267,264	212,358	-18
ADCP_4_Junction	7800	1,267,049	211,469	none available
Velocity Sampling Resolution:	1-m vertical bins			
Velocity Sampling Scheme:	10-minute average every 10 minutes			
Salinity Sampling Scheme:	Continuous at 10 Hz			
Velocity Transect Sampling[c]:	Continuous at 1 Hz			

Notes:

a Washington State Plane North, NAD83, feet

b Elevation is approximate. Estimated from current bathymetry data.

3.1.4 Results Memoranda (Task 4)

Anchor QEA will prepare a series of Results Memoranda that will include data summaries for geochronological cores (Task 1); Sedflume analyses (Task 2); and velocity, salinity, temperature, and bathymetry data (Task 3). The Results Memoranda will include raw data for each of those tasks. Interpretation of the data and results of the STE will be presented in the Sediment Transport Evaluation Report.

3.2 Sampling Methods

This section describes the methods for field studies to be conducted as part of Task 1 (geochronology field study), Task 2 (Sedflume field study), and Task 3 (velocity, salinity, temperature, and bathymetry data collection).

3.2.1 Identification Scheme for Sampling Locations

Each sampling location will be assigned a unique alphanumeric location identification (ID) number. The first two characters indicate the type of samples to be collected (i.e., GC for sediment cores for geochronology analysis and SF for sediment cores for Sedflume analysis), followed by a consecutive number identifying the specific location within the EW area. The 13 geochronology locations and 17 Sedflume locations will be numbered independently. Sample ID numbers are similar to location ID numbers, but also indicate the depth interval included in the sample. For example, the 0- to 1-cm section of the sediment core collected at location GC_1 would be called GC_1_0-1.

Sedflume cores will be analyzed as a continuous unit (i.e., no discrete sampling intervals), so the sample ID number will be the same as the location ID number for these cores.

Velocity and salinity profile sampling locations will be numbed sequentially with an added modifier to describe their relative location within the EW study area. A designator for type of data will be put first (ADCP for velocity and CTD for salinity), followed by a sequential number, followed by "North," "Middle," or "South" for the three proposed profile locations. Therefore, the velocity profile for the middle of the EW will be called ADCP_2_Middle and the corresponding CTD profile will be called CTD_2_Middle. Velocity profile samples will be a continuous time series with associated time and date stamps; therefore, no sample name will be required. Salinity profiles will be discrete samples taken multiple times over a tidal cycle. Samples will be named by adding an additional sequential-number designation to the location name for each batch of samples taken during the same tidal phase. Therefore, the first set of salinity profiles taken at the three proposed locations will be named CTD_1_North_1, CTD_1_Middle_1, and CTD_1_South_1.

Velocity transect locations will be named with an ADCP prefix, followed by the letter "X" to designate cross-channel direction or the letter "L" to designate the lateral (along-channel) direction. That letter will be followed by a sequential number. For example, the second cross-channel velocity transect would be named ADCP_X_2. As with the salinity profiles, the transect sample names will add an additional sequential number designation to the location name for each batch of samples taken during the same tidal phase. Therefore, the first set of velocity transects taken (there are a total of four proposed) will be named ADCP_X_1_1, ADCP_X_2_1, ADCP_X_3_1, and ADCP_L_1_1.

3.2.2 Location Positioning

Sampling locations for the cores, velocity measurements, and CTD casts will be located using a global positioning system (GPS). The GPS unit will be mounted on the winch arm used to collect the sediment cores. The GPS unit will receive GPS signals from satellites to produce positioning accuracy to within 3 meters. Washington State Plane

North coordinates (feet, North American Datum [NAD] 83) will be used for the horizontal datum.

The project vertical datum for determining elevation for the proposed data collection efforts will be MLLW (feet) based on the National Oceanic and Atmospheric Administration (NOAA) tidal benchmark for Seattle, Washington, Station ID# 9447130 (tidal epoch 1983-2001). The elevation of each sampling station will be determined relative to MLLW by measuring the water depth with a calibrated fathometer or lead line and correcting for tidal elevation. Tidal elevations used in the correction will be determined using water surface elevations collected as part of the hydrodynamic sampling task (from the moored ADCPs) or from real-time water level data collected at the NOAA tide gage (ID# 9447130) located south of Pier 53 in Elliott Bay at 47 36.1'N, 122 20.3' W. Tidal datum information relative to MLLW for the Seattle tide gage is summarized as follows:

- Mean higher high water (MHHW): 14.4 feet
- Mean high water (MHW): 11.3 feet
- Mean tide level (MTL): 6.6 feet
- Mean low water (MLW): 2.8 feet
- North American Vertical Datum (NAVD) 88: 2.3 feet
- MLLW: 0.0 feet

3.2.3 Geochronological Cores

Geochronological cores will be used to evaluate long-term stability and sedimentation rates, which are determined using radioisotope abundances of Cs-137 and Pb-210. Sediment cores will be collected using a piston core with a 4-inch (outer diameter) steel core tube and a butyl acetate core-tube liner (or polycarbonate) core tube operated by a diver. This type of corer is preferable over the gravity core method, as it minimizes the potential for compaction and disruption of the sample, and is typically easier to use. The core will be supported by a bracing structure and will be manually advanced by the diver into the sediment to achieve a target penetration depth of 90 cm with a minimum penetration of 78 cm, or to refusal. At each sample location, total water depth, penetration depth, and total sediment recovered will be measured and recorded in the field logbook. The time and date of core collection will also be recorded. Cores will be photographed through the clear liner, and the strata, visible organic material, and other features of each core will be documented and lithographic logs will be generated.

Following core collection, each high-resolution core will be split longitudinally and samples will be extracted in 2-cm increments using a hydraulic extruder jack, depending on sediment cohesion at a given sample location. The upper 2-cm section of each 6-cm segment will be sent for analysis and will be extracted from the core using clean spatulas to minimize contamination. The middle and bottom 2-cm sections of each 6-cm segment will be archived. The outer layer (0.25 to 0.5 cm) of each 2-cm section will be trimmed off the sample to avoid sampling any sediment that has come into contact with the wall of the core tube. Each 2-cm section will then be placed into a jar directly without homogenization.

This process will be repeated for each sediment sample interval, including those that will be archived. The physical characteristics of each sample interval will be determined by visual inspection in the field and recorded. These characteristics include general sediment type using the Unified Soil Classification System and approximate grain size (i.e., fine, medium, or coarse). (Further evaluation of grain size distribution will be completed in the laboratory using laser diffraction as described in Section 3.4). The sample will be placed into sample containers, labeled, and chilled at 4 degrees Celsius (°C).

Every third segment of the sediment core (e.g., 0-2 cm, 6-8 cm, 12-14 cm, etc.) will be submitted for laboratory analysis for Pb-210 and Cs-137, TOC, and total solids. Samples (2-cm-thick) that are not submitted for laboratory analysis will be archived in jars prepared identically to the samples that are submitted to the laboratory. The number of segments submitted for laboratory analysis per core will vary because of differences in total sediment core lengths collected. A maximum of 15 segments per core will be selected for laboratory analysis, which represents a maximum segment depth of 90 cm (or until refusal). Sample handling and analysis methods are described in Sections 3.3 and 3.4, respectively.

3.2.4 Sedflume Cores

Sedflume sediment cores with a minimum length of 30 cm will be obtained using the following procedure. A 10-cm x 15-cm rectangular core will be used during this study. Cores are inserted into a thin stainless steel sleeve. The neck of the sleeve is an outer rectangular tube (10 cm x 15 cm in size), while the main body is a box with dimensions such that the outer rectangular core tube fits tightly inside.

The assembled coring sleeve is lowered to the sediment bed using divers due to water depth. Pressure is applied to the top of the sleeve, causing the sleeve to penetrate into the sediment bed. The coring sleeve is then pushed as far as possible into the sediment bed; the distance of penetration will vary as a result of the characteristics of the sediment (i.e., deeper penetration will occur in softer sediment than in compact sediment). The objective of this process is to obtain a relatively undisturbed core. After retrieving the coring unit and bringing it onboard the sampling boat, the barrel is lifted off of the core tube. A plug is inserted into the core tube from the bottom (to act as a piston for later use in Sedflume) and the core is then capped. Sediment cores are transported and stored in an upright position. After sealing, each core is stored in an ambient temperature water bath to prevent the sediment from drying.

After capping, the cores will be visually inspected for length and quality. Sediment cores that show signs of disturbance during the coring process will be discarded and another core will be taken from the sampling location. Approved cores will be capped and stored on deck until the boat returns to the onshore processing site. At the processing site, samples taken from the core for bulk property analysis will be placed in appropriate containers, labeled, sealed, and preserved for analysis. The analysis will be completed on or near the project site and the appropriate equipment will be mobilized to the testing location. The sampling procedure for the bulk property samples is described below.

All sediment cores will be tested using Sedflume at the onshore processing site. Detailed descriptions of Sedflume and its use are given by McNeil et al. (1996). A schematic of Sedflume is shown in Figure 3-1; basically, this device is a straight flume that has a test section with an open bottom through which the rectangular coring tube containing sediment is inserted. The main components of the flume are the coring tube; the test section; the inlet section to create uniform, fully-developed, turbulent flow; the flow outlet section; the water storage tank; and the pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic so that the sediment-water interactions can be observed.

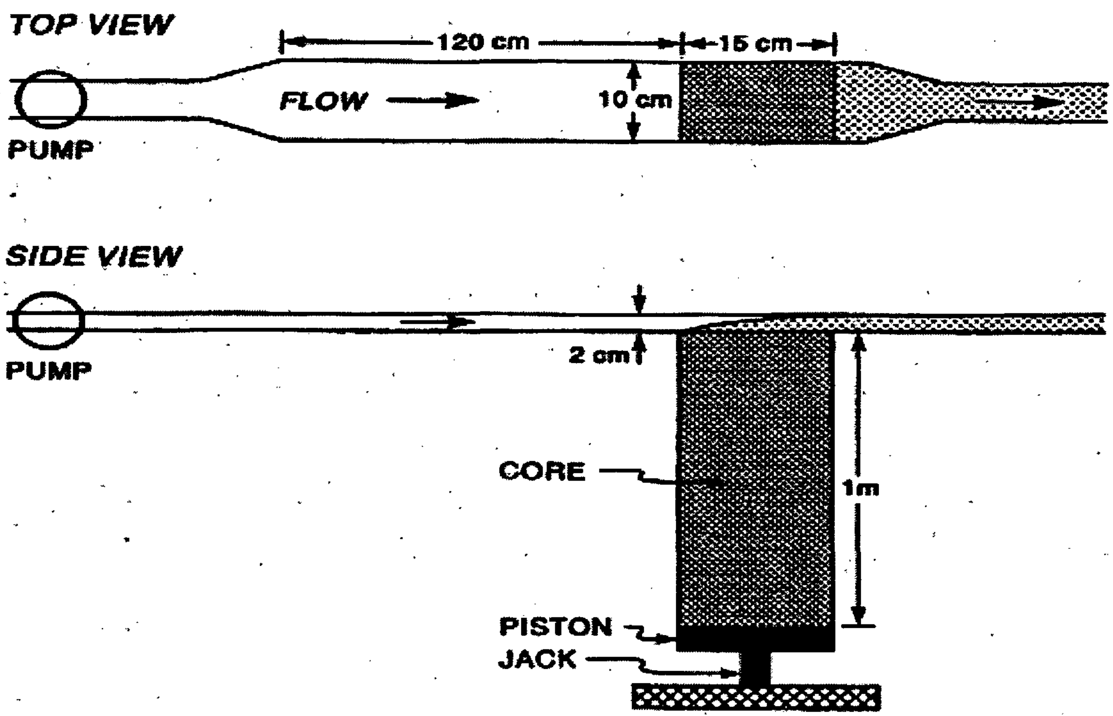

Figure 3-1 Schematic Diagram of Sedflume Apparatus (Sea Engineering 2008)

Prior to testing a core in Sedflume, a visual description of sediment in the core will be recorded. Bulk property subsamples for each core will be obtained from within the core; subsamples will be collected at the surface (prior to starting the first shear stress cycle) and after each shear stress cycle. Two 5-gram subsamples of sediment will be collected from the surface of the sediment core near the downstream edge of the test section. This sampling affects a small portion (i.e., less than 5 percent of the surface area) of the erosion surface of the core and, thus, has minimal impact on the test results. These subsamples will be obtained while the core is in the Sedflume by stopping flow within the device, opening up the Sedflume, and manually collecting the samples. The samples will be analyzed for particle size distribution using a laser particle size analyzer, TOC, and bulk density.

At the start of each test, the core is inserted into the bottom of the test section. An operator moves the sediment upward using a piston that is inside the core; the piston is connected to a hydraulic jack. By these means, the sediment in the core is raised and the sediment surface is positioned so that it is level with the bottom of the test section in Sedflume. The jack movement can be controlled in increments as small as 0.5 millimeters (mm).

Water is forced through the duct and the test section over the surface of the sediments. The shear stress produced by this flow may cause sediment to erode. A relationship between flow rate and shear stress in the test section has been developed (McNeil et al. 1996). As the sediment in the core erodes, the sediment core is moved upwards so that the sediment-water interface remains level with the bottom of the test section. The erosion rate is determined by measuring the amount of erosion (i.e., distance sediment is moved upward) in a specific amount of time.

In order to measure erosion rates at several different shear stresses using only one core, the following procedure is used. Starting at a low shear stress, the flume is run sequentially at higher shear stresses with each succeeding shear stress being twice the previous one. Generally, about four shear stresses are run sequentially during a particular shear stress cycle. Each shear stress is applied until at least 1 to 3 mm, but no more than 2 cm, of sediment are eroded, with each shear stress being applied for a minimum of 20 seconds and a maximum of 10 minutes. The amount of erosion (i.e., distance sediment is moved upward) and time are recorded for each shear stress. This procedure defines the minimum and maximum erosion rates to be 1.67×10^{-4} and 0.1 centimeters per second (cm/sec), respectively. The time interval is recorded for each cycle with a stopwatch. The flow is then increased to the next higher shear stress until the highest shear stress in the cycle is applied. This cycle is repeated until the top 30 cm of sediment in the core is eroded or, if the core is shorter than 30 cm, the entire core is eroded. If, after three shear stress cycles, an erosion rate of less than approximately 1.7×10^{-4} cm/sec occurs for a particular shear stress, that shear stress value is dropped from the cycle. If, after multiple cycles, the erosion rates decrease significantly, a higher shear stress is included in the cycle.

3.2.5 Velocity, Salinity, and Temperature Measurements

The velocity and salinity profiles and the velocity transects (both cross- and along-channel) will be collected in the EW study area to facilitate calibration of the hydrodynamic model. The specific methodology and the instrumentation for each type of data to be collected are described in Sections 3.2.6.1 through 3.2.6.3.

3.2.5.1 Velocity Profiles

The velocity profile measurements will be obtained at discrete locations within the EW study area. The vertical profiles of velocity within the EW will be collected with four upward-looking, continuous-sampling ADCP meters. These will be moored within the body of the EW (one in the Junction Reach south of the bridges, one in the Junction Reach north of the bridges, one just outside of Slip 27, and one at the north end of the EW) on an appropriately-designed mooring and installed to meet site-specific needs. These units use Doppler technology to measure the return frequency of an acoustic signal sent through the water to determine the water velocity at discrete distances along a line of sight away from the instrument. These instruments are capable of in situ, long-term data logging. It is anticipated that a SonTek/YSI Argonaut-XR or similar will be used for data collection.

The instruments will be in place for approximately 3 months, which should provide adequate data for model calibration and may capture a significant flow event from the Duwamish. If a significant flow event occurs within the first 2 months of deployment (flow from Duwamish equal to 8,000 cubic feet per second or greater), the instruments may be retrieved after the 2 month sampling period. The instruments will be moored in locations with the firmest soil available and in areas (or at elevations) where they are least likely to impact navigation. The elevation of the deployed ADCP will be determined by Anchor QEA or its subcontractor through conventional survey or based on the height of mooring and bottom elevation at the sampling location, depending on the water depth at the sampling location. The instruments will measure the velocity in three dimensions at 1-meter intervals, and the water depth above the sensor along the line of site of the sensor (water surface elevation). At the sampling location south of the bridges, it may be necessary to sample at intervals less than 1 meter. At this time, the bathymetry is unknown in that area, but is anticipated to be shallow. The sampling will be continuous at 1 hertz (Hz), with data logging of a 10-minute average every 10 minutes (six per hour). Post-processing of the velocity data will include outlier and appropriate statistical analyses to identify and remove samples that may be influenced by propeller wash.

3.2.5.2 Velocity Transects

Velocity transects will be collected for one sampling period over one complete tidal cycle. This will include a sampling period of approximately 24 contiguous hours. Due to planning and operational needs, it is not anticipated that any particular flow event will be captured during sampling. However, the sampling effort will be targeted toward larger tidal excursions and riverine flows, as feasible.

The cross-channel velocity transections will be collected at three cross-sections within the EW, aligned perpendicular to the centerline of the EW. Transects will be taken at about the same location along the EW as velocity profiles (moored instruments). All three transects must be completed within 1 hour to ensure that the data is synoptic relative to the tidal phase. The three transects will be completed once every 2 hours over one complete tidal cycle using a boat-mounted, downward-looking ADCP. An additional along-channel current transect in the EW between the bridges and Elliott Bay will be collected in the hour following the cross-channel transects using the same instrumentation. Like the cross-channel transects, the along-channel transect will be completed once every 2 hours, but in between the data collection for the cross-channel transects. This will maximize the volume of synoptic data collected in the EW study area utilizing a single vessel and instrument. It is anticipated that velocity transects will be collected with a SonTek/YSI ADP with bottom tracking and GPS input for moving boat applications (or similar). The instruments will measure the velocity in three dimensions at 1-meter intervals and the distance below the sensor along the line of sight of the instrument. Depending on the weather conditions during the scheduled sampling window, one high-flow and one low-flow event and spring/ mean/neap tidal cycles will be targeted for sampling.

3.2.5.3 Salinity and Temperature Profiles

Vertical profiles of salinity and temperature will be collected using a YSI 6920 V2-2 (or similar), which will measure salinity (conductivity), temperature, and depth (pressure) in real-time. The data are collected by lowering the instrument through the water column at each sampling location. It is anticipated that the instrument will log the data continuously at a sampling frequency of 25 Hz. Data will be collected during both the downcast and upcast at each sampling location. The line speed for the casts will be determined by the response time of the temperature, conductivity, and depth sensors on the instrument. The response time will be dependant upon final equipment selection and availability at the time that data are collected. For the equipment suggested above, the response time for the depth and conductivity sensors is close to instantaneous, while the temperature sensor takes 30 seconds to reach 90 percent of the parameter value (per telephone conversation with YSI technical support, January 8, 2009). Equipment chosen for collection of salinity and temperature data should meet this minimum response time criterion. These data will be collected over one complete tidal cycle at approximately the same location as the velocity profiles. The profiles will be completed during the ADCP cross-channel transects and at the same frequency, every 2 hours. Depending on the weather conditions during the scheduled sampling window, one high-flow and one low-flow event and spring/ mean/neap tidal cycles will be targeted for sampling.

3.2.5.4 General Field Sampling Considerations

The following general procedures for operating in situ instruments have a direct influence on data quality and apply for most instruments:

- The sealing parts of all underwater connectors and housings should be cleaned and coated with silicone grease to ensure proper lubrication and watertight integrity.
- Cables should be inspected for nicks, cuts, abrasions, and other signs of physical damage, and repaired as needed, prior to deployment.
- Desiccant should be inspected and replaced as needed.
- Battery condition should be checked periodically.
- Sensors should be housed in a way to protect from direct impact but allow for unrestricted water flow around sensors.

- Optical surfaces should be cleaned with a detergent, rinsed, and dried prior to deployment.
- During deployment, the vessel should maintain its position.
- Sensors should be deployed from a part of the vessel that is outside the immediate influence of the propwash and other vessel contaminant sources (bilge pumps).
- Sensors should be rinsed with fresh water after each sampling event.
- External sensors should be covered for protection when not in use.
- Instruments should be safely secured when on deck.

For sufficient data collection and proper maintenance of the moored data collection equipment, the servicing and downloading of data will be performed at an interval of approximately 21 days during the data collection period. At no time should the interval exceed 28 days due to instrument limitations, such as memory or battery life, in order to offset the potential for any data loss caused by malfunction, loss, damage, or other circumstances.

3.2.6 Targeted Bathymetry Data

Bathymetry data will be collected in the vicinity of the Sill Reach where no data presently exist (see Figure 2-4 in the STEAM, Anchor and Battelle 2008a). The approximate area where bathymetry data will be collected is between EW Stations 6800 and 7600 (see Map 1-1). If possible, additional bathymetry between EW Stations 6000 and 6800 will be collected. A portion of this area, between stations 6800 and 7200, is located underneath several bridges that have very little overhead freeboard. These constraints may limit the types of survey equipment that may be utilized in those areas. It is anticipated that high-resolution single- or multi-beam equipment will be used to collect the data outside of influence of the bridges; however, it may be necessary to use lead-line, or other methods to collect the required information between Stations 6800 and 7200. The horizontal and vertical datum standards for the bathymetry data are discussed in Section 3.2.2. Field methodology for the bathymetry measurements will follow the standards of practice as outlined in the U.S. Army Corps of Engineers (USACE) Hydrographic Surveying engineering and design report (USACE 2001).

3.3 Sample Handling Requirements

This section provides descriptions of how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analysis. In addition, this section describes decontamination procedures, field-generated waste disposal, and shipping and sample custody requirements.

3.3.1 Sample Handling Procedures

Geochronology samples will be placed in appropriately sized, certified-clean, wide-mouth glass jars and capped with Teflon®-lined lids. Jars will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. A minimum of 50 grams (wet) and 10 grams (wet) of sediment are required for the radiological and conventional analyses, respectively. Prior to shipment, each glass container for conventional analyses will be wrapped in bubble wrap and placed in a cooler with wet ice. There are no temperature requirements for sediment samples to be analyzed for radioisotopes, so each glass container for radiological analysis will be wrapped in bubble wrap and placed in a cooler without ice. Each jar will be sealed, labeled, and stored under appropriate conditions.

Sedflume samples will be collected, handled, and analyzed by SEI personnel. COC will be recorded as required by Section 3.3.4. For each Sedflume core, two 5-gram aliquots will be removed for grain size and total solids analyses and placed on aluminum weighing pans. After weighing, each aliquot for grain size analysis will be transferred to a 10-millileter Whirlpak. Aliquots for total solids analysis will be analyzed in the same processing facility used for the Sedflume analysis, so no special sample handling or shipping will be necessary for these samples. All samples will be uniquely labeled and logged by the sampler. Samples designated for Sedflume study will be under the continuous custody of SEI personnel so the sample integrity can be assured. Dr. Craig Jones of SEI will supervise all Sedflume operations. Table 3-4 summarizes sample container requirements for all proposed sediment cores.

Table 3-4
Sample Containers

Parameter	Container	Laboratory	Cores to Analyze
Cs-137 and Pb-210	4-oz glass jar	Mass Spec Services	Geochronology
TOC and total solids	4-oz glass jar	ARI	Geochronology
Grain Size	10-ml Whirlpak	ARI	Sedflume

Sample labels will be waterproof and self-adhering. Each sample label will contain the project number, sample identification, analyses, date and time of collection, and initials of the person(s) preparing the sample. A completed sample label will be affixed to each sample container. The labels will be covered with clear tape immediately after they have been completed to protect them from being stained or spoiled from water and/or sediment.

At each laboratory, a unique sample identifier will be assigned to each sample (using either project ID or laboratory ID). The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and the type of analysis being performed.

3.3.2 Decontamination Procedures

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments used that are in direct contact with the sediment collected for analysis will be made of glass, stainless steel, or high density polyethylene (HDPE), and will be cleaned prior to each day's use and between sampling or compositing events. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces. Decontamination of all items will follow Puget Sound Estuary Program (PSEP) protocols. The decontamination procedure is as follows:

- Pre-wash rinse with site water
- Wash with solution of site water and Alconox soap (brush)
- Rinse with site water

- Rinse three times with distilled water
- Cover (no contact) all decontaminated items with aluminum foil
- Store in clean, closed container for next use

The analytical laboratory will provide certified, pre-cleaned containers for all samples. Prior to shipping, the analytical laboratory will add preservative, where required.

3.3.3 Field-generated Waste Disposal

Excess sediment, generated equipment rinsates, and decontamination water will be returned to each sampling location after sampling is completed for that location. All disposable sampling materials and personal protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

3.3.4 Shipping Requirements and Chain-of-Custody

All containerized sediment samples will be transported to the analytical laboratory after preparation is completed. Specific sample shipping procedures will be as follows:

- Each cooler or container containing the sediment samples for analysis will be delivered to the laboratory within 24 hours of being sealed.
- Individual sample containers will be placed in a sealable plastic bag, packed to prevent breakage, and transported in a sealed ice chest or other suitable container.
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
- Glass jars will be separated in the shipping container by shock-absorbent material (e.g., bubble wrap) to prevent breakage.
- A sufficient amount of ice will be double-bagged in sealable plastic bags and placed within the cooler.
- A sealed envelope containing COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.

- Signed and dated COC seals will be placed on all coolers prior to shipping.

The persons transferring custody of the sample container will sign the COC form upon transfer of sample possession to the analytical laboratory. The shipping container seal will be broken upon receipt of samples at the laboratory and the receiver will record the condition of the samples. COC forms will be used internally by the laboratory to track sample handling and final disposition. It is essential that the possession of the samples be traceable from the time they are collected through analysis. Samples are considered to be "in custody" if they are:

- In the custodian's possession or view;
- Retained in a secured place (under lock) with restricted access; or
- Placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s).

The principal documents used to identify samples and to document possession are custody records and seals, field logbooks, and field tracking forms. Custody procedures will be initiated during sample collection. A custody record will accompany each sample. Each person who has custody of the samples will sign the custody form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- Sample location, project name, and unique sample number
- Sample collection date and time
- Any special notations on sample characteristics or problems
- Description of analysis to be performed
- Initials of the person collecting the sample
- Date sample was sent to the laboratory

3.4 Laboratory Methods

This section discusses standard analytical methods and DQIs for laboratory analyses.

3.4.1 Analytical Methods

Analytical methods and holding times are presented in Table 3-5. One sample container from each geochronology sediment core segment will be submitted to Mass Spec

Services (Orangeburg, New York) for Pb-210 and Cs-137 analyses. The other sample container from each geochronology sediment core segment will be submitted to ARI (Tukwila, Washington) for grain size distribution, TOC content, and total solids analyses. Geochronology sediment core segments not selected for laboratory analyses will be archived at room temperature for future analyses, if needed.

Five-gram samples from each Sedflume core will be analyzed for total solids and sediment grain size, according to the methods in Table 3-5. Grain size distribution analysis will be conducted by SEI using laser diffraction analysis. Samples collected from the Sedflume core are prepared and sieved at 2,000 mm. Any fraction over 2,000 mm is weighed and compared to total sample weight to determine the weight percentage by weight greater than 2,000 mm. The fraction of the sample less than 2,000 mm is analyzed in a Beckman Coulter LS 13 320 using measurement of laser diffraction through an aqueous suspension of the sample. Each sample is analyzed in three 1-minute intervals and the results of the four analyses are averaged. The instrument is tested daily with a controlled standard and all manufacturer specifications for instrument operation are met or exceeded in the SEI laboratory.

Dry density will be estimated for Sedflume samples, according to Equation 3-3, in the processing facility used to analyze the Sedflume core samples. The same equation will be used to estimate dry density for the geochronology sediment samples using the total solids data generated by ARI.

$$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W} \qquad \textbf{Equation 3-3}$$

Where:

ρ_b = dry density (g/cm^3)

ρ_w = density of water (g/cm^3)

ρ_s = density of sediment particles (assumed 2.65 g/cm^3)

W = water content (i.e., 1-total solids expressed as a unit-less fraction)

Table 3-5
Laboratory Analytical Methods and Maximum Holding Times

Parameter	Method	Maximum Holding Time	Preservative
Pb-210	Radiochemical isolation/beta assay of Bi-210 daughter product	1 year	None
Cs-137	Direct gamma spectral analysis	1 year	None
TOC	Plumb (1981)	28 days	Cool / 4 °C
		6 months	Freeze / -18 ° C
Dry density	See Equation 3-3	Calculated – no field sample	Calculated – no field sample
Total Solids	EPA 160.3	14 days	Cool / 4 °C
		6 months	Freeze / -18 ° C
Sediment grain size	Laser Diffraction (Beckman Coulter LS 13 320)	6 months	Cool / 4 °C

3.4.2 Data Quality Indicators

The DQO for this project is to ensure that the data collected are of known and acceptable quality so that the project objectives described in the Workplan (Anchor and Windward 2007) can be achieved. The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable QC procedures are given below. Applicable quantitative goals for these data quality parameters are listed or referenced in Table 3-6.

Table 3-6
Data Quality Indicators for Sediment Analyses

Parameter	Precision	Accuracy	Completeness	Sensitivity (Method Detection Limit)
Pb-210	± 30%	70 - 130%	95%	0.2 piC/g dw
Cs-137	± 30%	70 - 130%	95%	0.2 piC/g dw
TOC	± 30%	70 - 125%	95%	0.01% dw
Dry density	± 20%	na	95%	0.01 g/cm^3
Total Solids	± 20%	na	95%	0.1% ww
Sediment grain size	± 30%	na	95%	0.1% dw

Note:
na – not applicable

3.4.2.1 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling, and in laboratory analysis. The American Society for Testing and Materials (ASTM; 2002) recognizes two levels of precision: repeatability—the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions; and reproducibility—the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

In the laboratory, "within-batch" precision is measured using replicate sample or QC analyses and is expressed as the RPD between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

Field precision will be evaluated by the collection of blind field duplicates for chemistry samples at a frequency of one in 20 samples. Field chemistry duplicate precision will be screened against an RPD of 50 percent for sediment samples and 35 percent for water samples. However, no data will be qualified based solely on field homogenization duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the MDL, where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2} \qquad \textbf{Equation 3-4}$$

Where:

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values

3.4.2.2 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions. In addition, laboratory-fortified (i.e., matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as %R of the measured value, relative to the true or expected value. If a measurement process produces results for which the mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). Analytical laboratories utilize several QC measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples, and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

Laboratory accuracy will be evaluated against quantitative matrix spike and surrogate spike recovery performance criteria provided by the laboratory. Accuracy can be expressed as a percentage of the true or reference value, or as a %R in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$ **Equation 3-5**

Where:

%R = percent recovery

S = measured concentration in the spiked aliquot

U = measured concentration in the unspiked aliquot

C_{sa} = actual concentration of spike added

3.4.2.3 *Bias*

Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Bias assessments for environmental measurements are made using personnel, equipment, and spiking materials or reference materials as independent as possible from those used in the calibration of the measurement system. When possible, bias assessments should be based on analysis of spiked samples rather than reference materials so that the effect of the matrix on recovery is incorporated into the assessment. A documented spiking protocol and consistency in following that protocol are important to obtaining meaningful data quality estimates.

3.4.2.4 *Representativeness*

Representativeness expresses the degree to which data accurately and precisely represents an environmental condition. For the East Waterway, the number of samples and spatial and temporal extent of sampling has been chosen to provide an appropriate level of information for calibration of the hydrodynamic model and empirical estimates of net sedimentation rate and critical shear stresses.

3.4.2.5 *Comparability*

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. For this program, comparability of data will be established through the use of standard analytical methodologies and reporting formats, and of common traceable calibration and reference materials.

3.4.2.6 *Completeness*

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{(\text{Number of acceptable data points}) \times 100}{(\text{Total number of data points})}$$ **Equation 3-6**

The DQO for completeness for all components of this project is 90 percent. Data that have been qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

3.4.2.7 *Sensitivity*

Analytical sensitivities must be consistent with or lower than the regulated criteria values in order to demonstrate compliance with this QAPP. When they are achievable, target detection limits specified in this QAPP will be at least a factor of 2 less than the analyte's corresponding regulated criteria value.

The MDL is defined as the minimum concentration at which a given target analyte can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. Laboratory practical quantitation limits (PQLs) or RLs are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. Laboratory MDLs and RLs will be used to evaluate the method sensitivity and/or applicability prior to the acceptance of a method for this program.

The sample-specific MDL and RL will be reported by the laboratory and will take into account any factors relating to the sample analysis that might decrease or increase the RL (e.g., dilution factor, total solids, sample volume, and sparge volume). In the event that the MDL and RL are elevated for a sample due to matrix interferences and subsequent dilution or reduction in the sample aliquot, the data will be evaluated by Anchor QEA and the laboratory to determine if an alternative course of action is required or possible. If this situation cannot be resolved readily (i.e., detection limits less than criteria are achieved), EPA will be contacted to discuss an acceptable resolution.

3.5 Quality Assurance/Quality Control

Field and laboratory activities must be conducted in such a manner that the results meet specified quality objectives and are fully defensible. Guidance for QA/QC is derived from the protocols developed for the EPA SW-846 (1986), the EPA Contract Laboratory Program, U.S. Department of Energy validation guidance (TPR-80-SOP-12.1.2) for radiological compounds, and the cited methods.

3.5.1 Duplicates

Field duplicates are generally used to evaluate the variability attributable to sample handling. Field duplicate samples will be collected according to the frequency described in Table 3-7 by splitting the homogenized sediment from a single sample into two identical samples.

Table 3-7
Quality Control Samples

Parameter	Field Duplicate	Method Blank	Matrix Replicates	Laboratory Control Standard	Matrix Spike	Matrix Spike Duplicate
Pb-210	1/20	1/20	1/20	1/20	1/20	1/20
Cs-137	1/20	1/20	1/20	1/20	1/20	1/20
TOC	1/20	1/20	1/20	1/batch	na	na
Bulk density	1/20	na	1/20	na	na	na
Total Solids	1/20	na	1/20	na	na	na
Sediment grain size	1/20	na	1/20	na	na	na

Note:
na – not applicable

3.5.2 Laboratory QA/QC

Laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials, laboratory control samples, matrix replicates, matrix spikes/matrix spike duplicates (MS/MSDs), surrogate spikes (for organic analyses), and method blanks. Results of the QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the QA Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

3.6 Field Instrument/Equipment Calibration

Field equipment will be calibrated prior to each sampling event according to manufacturer's recommendations using manufacturer's standards. A calibration check will be performed at the end of the day. The equipment, calibration, and maintenance information will be documented in the instrument calibration log. The frequency of calibration is dependent on the type and stability of the equipment, the methods used, the intended use of the equipment, and the recommendations of the manufacturer. Detailed information regarding the calibration and frequency of equipment calibration is provided in specific manufacturer's instruction manuals.

Equipment that fails calibration (according to manufacturer's recommendations and standards) or becomes inoperable during use will be removed from service and tagged (time and date of action) to prevent inadvertent use. Such equipment will be satisfactorily recalibrated or repaired and tagged (date and time of return to service) prior to use.

3.7 Inspection/Acceptance of Supplies and Consumables

Inspection and acceptance of field supplies, including laboratory-prepared sampling bottles, will be performed by the FC. All primary chemical standards and standard solutions used in this project either in the field or laboratory will be traceable to documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities found in the standard will be documented.

3.8 Data Management

Field data sheets will be checked for completeness and accuracy by the FC prior to delivery to the Data Manager. All data generated in the field will be documented on hard copy and provided to the Anchor QEA Data Manager, who is responsible for entering sediment data into the database. All manually entered data will be checked by a second party. Field documentation will be filed in the main project file after data entry and checking are complete. ADCP (velocity) and CTD (salinity and temperature) data will be provided to the Anchor QEA Data Manager but will not be included in the sediment database.

Laboratory data will be provided to the Data Manager in the EQuIS electronic format. Laboratory data, which is electronically provided and loaded into the database, will undergo a 10 percent check against the laboratory hard copy data. Data will be validated or reviewed manually, and qualifiers, if assigned, will be entered manually. The accuracy of all manually entered data will be verified by a second party. Data tables and reports will be exported from EQuIS to Microsoft Excel tables.

4 ASSESSMENTS AND RESPONSE ACTIONS

Once data are received from the laboratory, a number of QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

A full data quality review will be performed by LDC, in accordance with *EPA National Functional Guidelines* (EPA 1999, 2004, and 2005). The data will be evaluated in accordance with this QAPP. All chemical data will be reviewed with regard to the following, as appropriate to the particular analysis:

- COC documentation
- Holding times
- Instrument calibration
- Method blanks
- Detection limits
- RLs
- Surrogate recoveries
- MS/MSD recoveries
- Laboratory control sample recoveries
- Laboratory and field duplicate RPDs

The results of the data quality review, including text assigning qualifiers in accordance with the *EPA National Functional Guidelines* and a tabular summary of qualifiers, will be generated by the Data Manager and submitted to the project QA/QC Manager for final review and confirmation of the validity of the data (EPA 1999, 2004, and 2005). A copy of the LDC validation report will be submitted by the QA/QC Manager and will be presented as an appendix to the Results Memoranda.

4.1 Compliance Assessments

Laboratory and field performance audits consist of on-site reviews of QA systems and equipment for sampling, calibration, and measurement. Laboratory audits will not be conducted as part of this study; however, all laboratory audit reports will be made available to the project QA/QC Manager upon request. The laboratory is required to have written procedures addressing internal QA/QC; these procedures have been submitted and will be reviewed by the project QA/QC Manager to ensure compliance with the QAPP. The laboratory must ensure that personnel engaged in sampling and analysis tasks have appropriate training. The laboratory will, as part of the audit process, provide for consultant's review written details of any and all method modifications planned.

4.2 Response and Corrective Actions

The following paragraphs identify the responsibilities of key project team members and actions to be taken in the event of an error, problem, or nonconformance to protocols identified in this document.

4.2.1 Field Activities

The FC will be responsible for correcting equipment malfunctions during the field sampling effort. The project QA/QC Manager will be responsible for resolving situations identified by the FC that may result in noncompliance with this QAPP. All corrective measures will be immediately documented in the field logbook.

4.2.2 Laboratory

The laboratory is required to comply with their standard operating procedures (SOPs). The Laboratory Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

The Laboratory Manager will be notified immediately if any QC sample exceeds the project-specified control limits. The analyst will identify and correct the anomaly before continuing with the sample analysis. The Laboratory Manager will document the corrective action taken in a memorandum submitted to the QA/QC Manager within 5 days of the initial notification. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package in the form of a cover letter.

4.3 Reports to Management

QA reports to management include verbal status reports, written reports on field sampling activities and laboratory processes, data validation reports, and final project reports. These reports shall be the responsibility of the QA/QC Manager.

Progress reports will be prepared by the FC following each sampling event. The project QA/QC Manager will also prepare progress reports after the sampling is completed and samples have been submitted for analysis, when information is received from the laboratory, and when analysis is complete. The status of the samples and analysis will be indicated with emphasis on any deviations from the QAPP. A data report will be written after validated data are available for each sampling event. These reports will be delivered electronically to the Anchor QEA PM.

5 DATA VALIDATION AND USABILITY

This section describes the processes that will be used to review project data quality.

5.1 Data Review, Validation, and Verification

During the validation process, analytical data will be evaluated for method QC and laboratory QC compliance, and its validity and applicability for program purposes will be determined. Based on the findings of the validation process, data validation qualifiers may be assigned. The validated project data, including qualifiers, will be entered into the project database, thus enabling this information to be retained or retrieved, as needed.

5.2 Validation and Verification Methods

Data validation includes signed entries by the field and laboratory technicians on field data sheets and laboratory datasheets, respectively; review for completeness and accuracy by the FC and Laboratory Manager; review by the Data Manager for outliers and omissions; and the use of QC criteria to accept or reject specific data. All data will be entered into the EQuIS database and a raw data file printed. One hundred percent verification of the database raw data file will be performed by a second data manager or designee. Any errors found will be corrected on the raw data printout sheet. After the raw data are checked, the top sheet will be marked with the date the checking is completed and the initials of the person doing the checking. Any errors in the raw data file will be corrected, and the database established.

All laboratory data will be reviewed and verified to determine whether all DQOs have been met, and that appropriate corrective actions have been taken, when necessary. The project QA/QC Manager or designee will be responsible for the final review of all data generated from analyses of samples.

The first level of review will take place in the laboratory as the data are generated. The laboratory department manager or designee will be responsible for ensuring that the data generated meet minimum QA/QC requirements and that the instruments were operating under acceptable conditions during generation of the data. DQOs will also be assessed at this point by comparing the results of QC measurements with pre-established criteria as a measure of data acceptability.

The analysts and/or laboratory department manager will prepare a preliminary QC checklist for each parameter and for each sample delivery group (SDG) as soon as analysis of an SDG has been completed. Any deviations from the DQOs listed on the checklist will be brought to the attention of the Laboratory Manager to determine whether corrective action is needed and to determine the impact on the reporting schedule.

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that all data and QA/QC information requested are present. Data quality will be assessed by a reviewer using current *EPA National Functional Guidelines* data validation requirements (EPA 1999, 2004, and 2005) by considering the following:

- Holding times
- Initial calibrations
- Continuing calibrations
- Method blanks
- Surrogate recoveries
- Detection limits
- RLs
- Laboratory control samples
- MS/MSD samples
- Standard reference material results

The data will be validated in accordance with the project-specific DQOs described above, analytical method criteria, and the laboratory's internal performance standards based on their SOPs.

5.3 Reconciliation with User Requirements

The QA/QC Manager will review data to determine if DQOs have been met. If data do not meet the project's specifications, the QA/QC Manager will review the errors and determine if the problem is due to calibration/maintenance, sampling techniques, or other factors, and will suggest corrective action. It is expected that the problem would be able to be corrected by retraining, revision of techniques, or replacement of supplies/equipment; if not, the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the QA/QC

Manager will recommend appropriate modifications. Any revisions will require approval by EPA.

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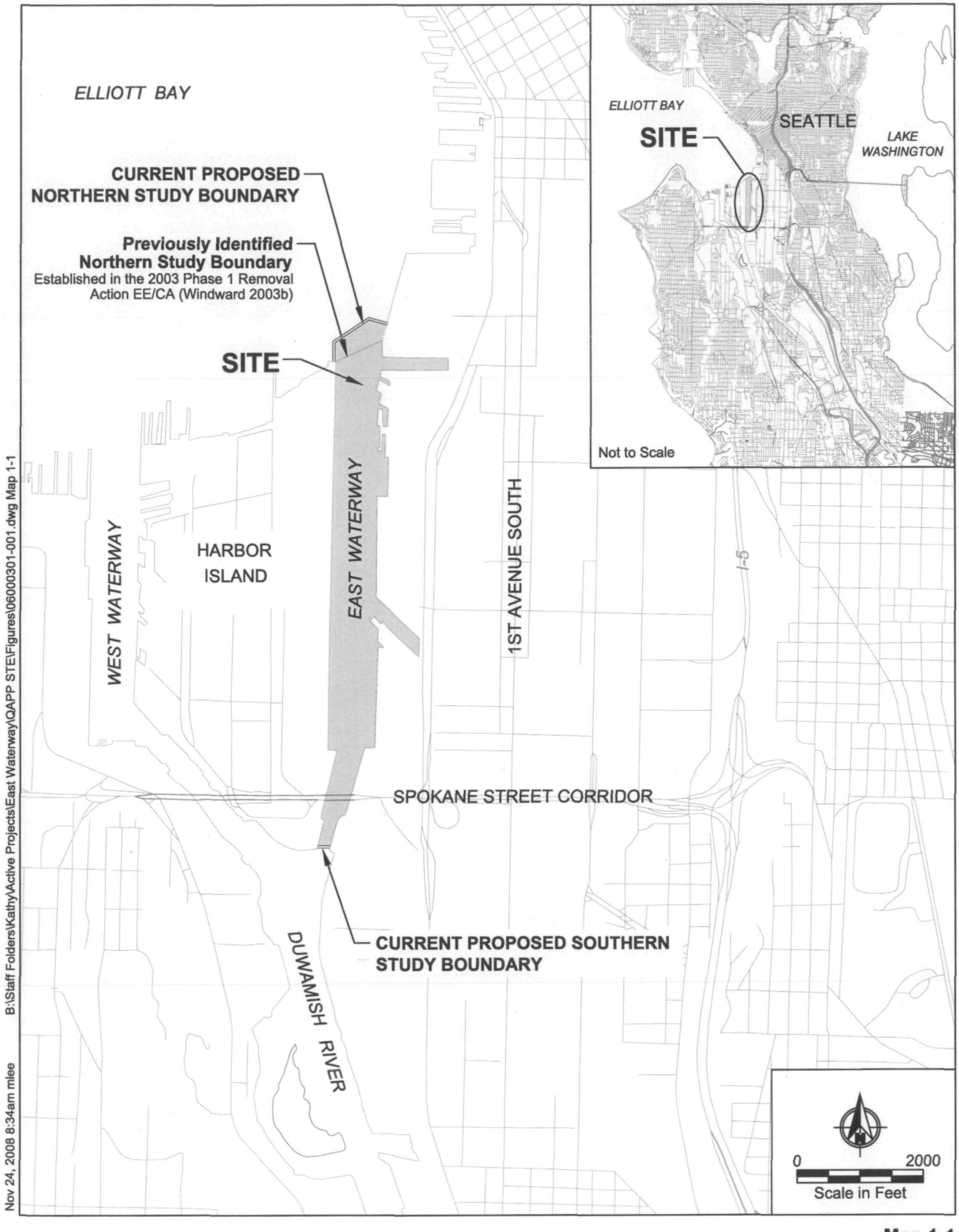
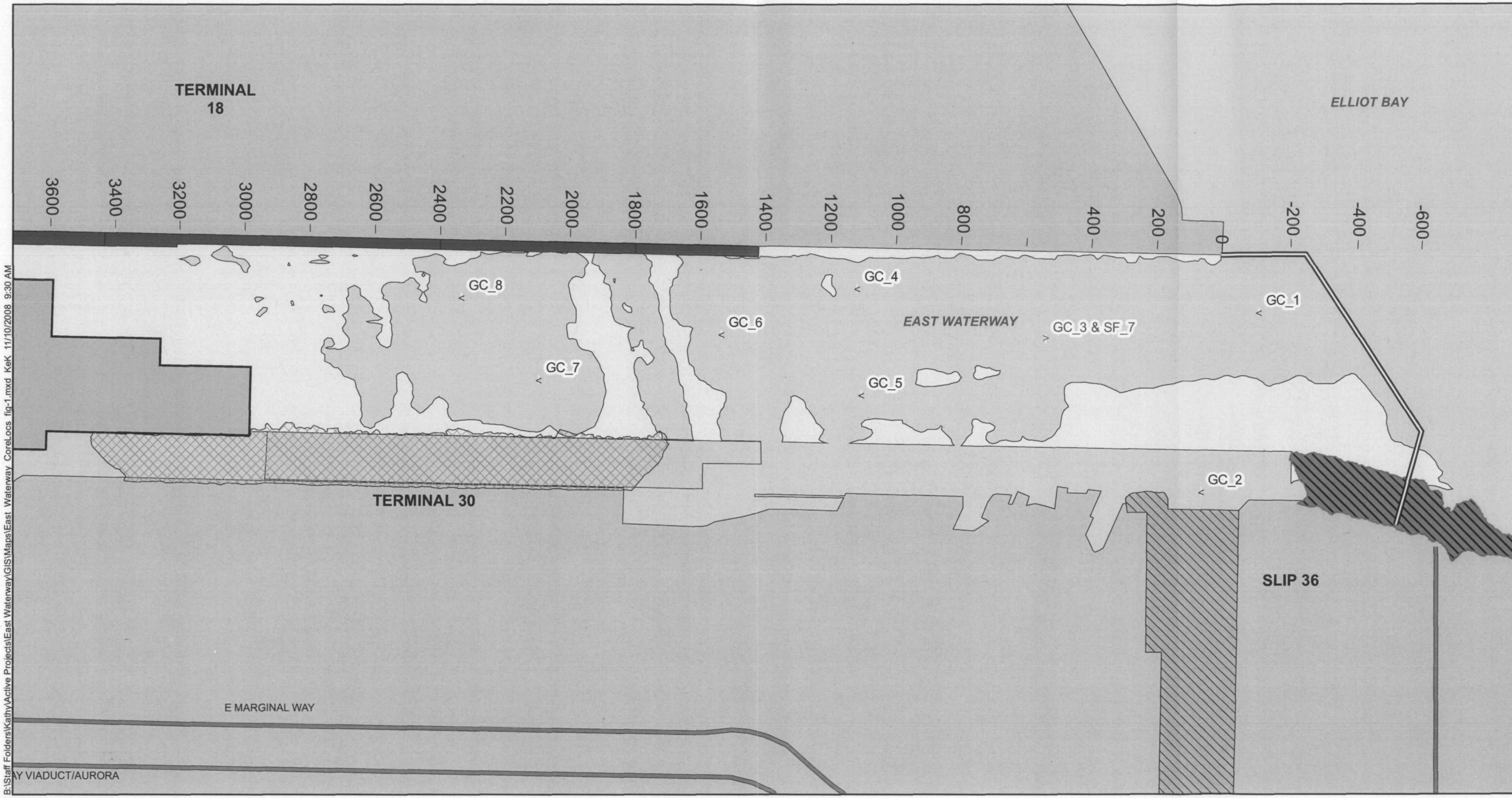
APPENDIX A

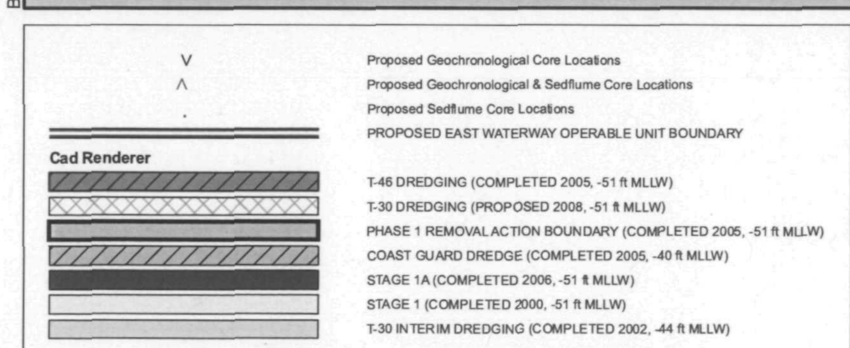
MAPS

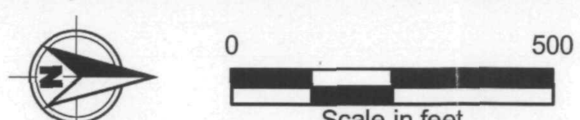


Map 1-1
Vicinity Map and Proposed East Waterway Operable Unit Study Boundary
Quality Assurance Project Plan, Sediment Transport Characterization
East Waterway Operable Unit

B:\Staff Folders\Kathy\Active Projects\East Waterway\GIS\Maps\East Waterway CoreLocs fig-1.mxd KeK 11/10/2008 9:30 AM

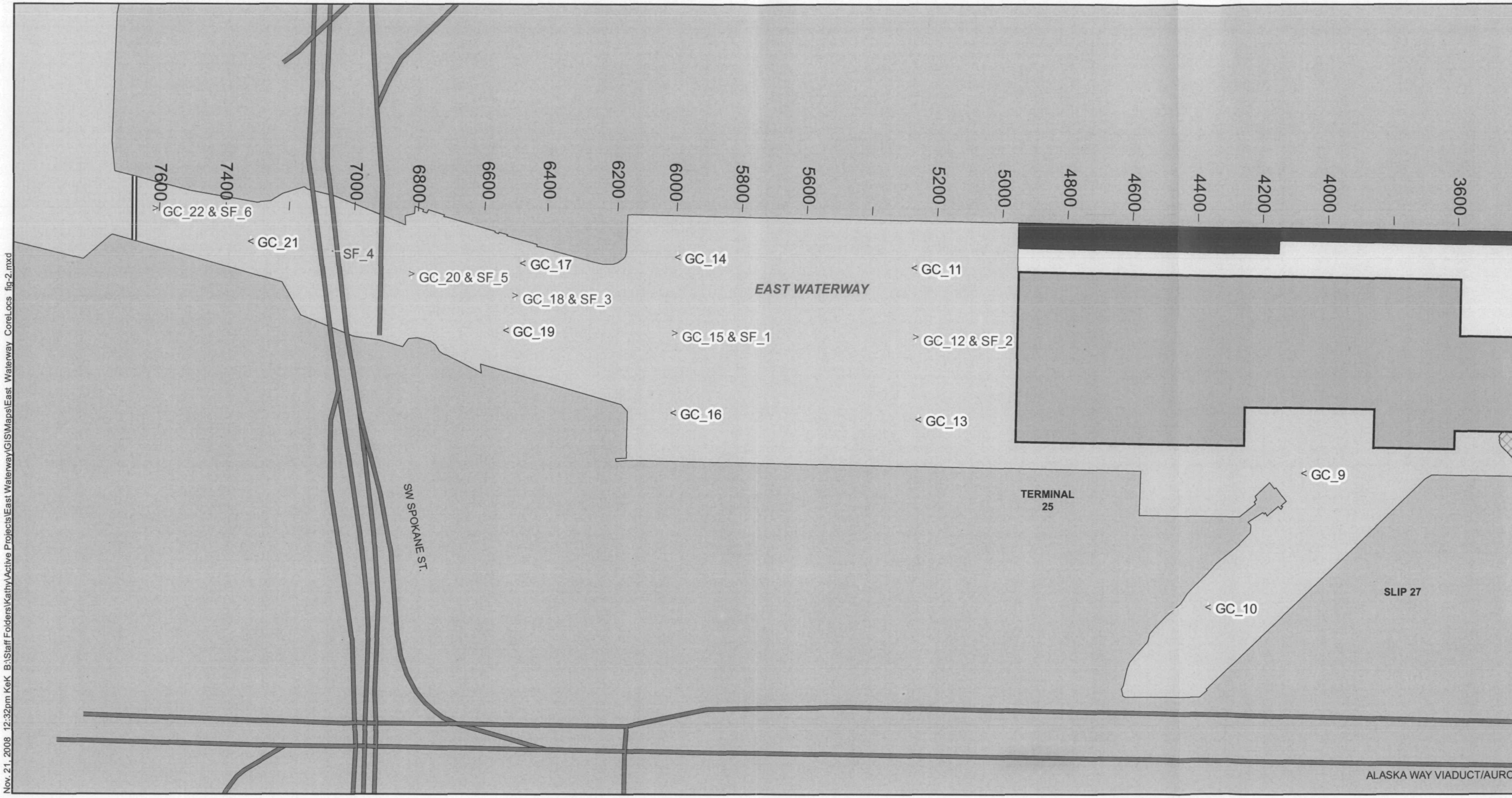






Note: Previously established station locations for the East Waterway are shown along the western shoreline for reference

MAP 3-1
Proposed Geochronological and Sedflume Core Locations, EW Station -600 through 3600
QAPP Sediment Transport Characterization
East Waterway Operable Unit



V Proposed Geochronological Core Locations
Λ Proposed Geochronological & Sedflume Core Locations
. Proposed Sedflume Core Locations
PROPOSED EAST WATERWAY OPERABLE UNIT BOUNDARY

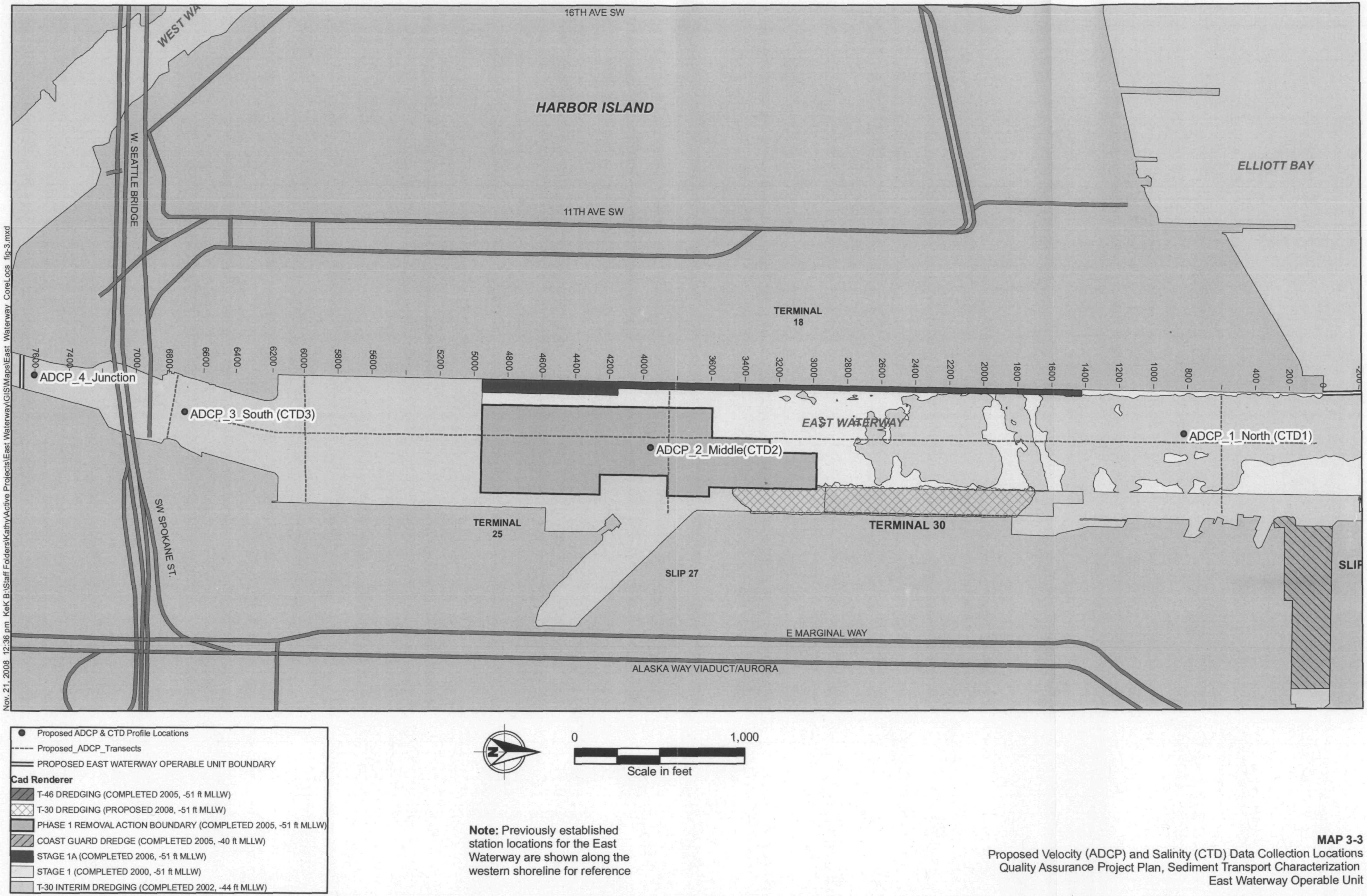
Cad Renderer

T-46 DREDGING (COMPLETED 2005, -51 ft MLLW)
T-30 DREDGING (PROPOSED 2008, -51 ft MLLW)
PHASE 1 REMOVAL ACTION BOUNDARY (COMPLETED 2005, -51 ft MLLW)
COAST GUARD DREDGE (COMPLETED 2005, -40 ft MLLW)
STAGE 1A (COMPLETED 2006, -51 ft MLLW)
STAGE 1 (COMPLETED 2000, -51 ft MLLW)
T-30 INTERIM DREDGING (COMPLETED 2002, -44 ft MLLW)

0 500
Scale in feet

Note: Previously established station locations for the East Waterway are shown along the western shoreline for reference

MAP 3-2
Proposed Geochronological and Sedflume Core Locations, EW Station 3600 through 7600
Quality Assurance Project Plan, Sediment Transport Characterization
East Waterway Operable Unit



Note: Previously established station locations for the East Waterway are shown along the western shoreline for reference

MAP 3-3
Proposed Velocity (ADCP) and Salinity (CTD) Data Collection Locations
Quality Assurance Project Plan, Sediment Transport Characterization
East Waterway Operable Unit

APPENDIX B

HEALTH AND SAFETY PLAN

(To be provided to EPA under separate cover)

APPENDIX C

SAMPLE FORMS

Daily Log

ANCHOR ENVIRONMENTAL, L.L.C.

Anchor Environmental, L.L.C.
1423 3rd Avenue Suite 300
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

DATE: ______________________

PROJECT NAME: ______________________ **PERSONNEL:** ______________________

PROJECT NUMBER: ______________________ **SUB-CONTRACTOR:** ______________________

WEATHER:	**WIND FROM:**	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
		SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	° F	° C

[Circle appropriate units]

TIME	COMMENTS

Signature: ______________________

Soil Boring Processing Log

ANCHOR ENVIRONMENTAL, L.L.C.

Boring Location: Elevation: Datum:	Boring ______ Date ____ Sheet ____ of ____ Job ______________ Job No. ________ Logged By __________ Weather ________ Drilled By ______________________ Drill Type/ Method ___________________ Sampling Method Bottom of Boring ________ ATD Water Level Depth
Obs. Well Install. Yes No	

SIZE (%)			PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION: Den., moist., color, minor, MAJOR CONSTITUENT, NON-SOIL SUBSTANCES: Odor, staining, sheen, scrag, slag, etc.	REMARKS: Drill action, drill and sample procedures, water conditions, heave, etc.	SUMMARY LOG (Water & Date)
G	S	F										
Max.	Range	Att. Limits		From	To	Type	Number					
								0				
								1				
								2				
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				
								1				
								2				
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				

Sediment Core Processing Log

COC ID #

ANCHOR ENVIRONMENTAL, L.L.C.

Job:	Date Logged:
Job No.:	Core Pushed By:
Station ID:	Core Logged By:
	Type of Core: ☐ Vibracore ☐ Piston Core ☐ Other
No. of Sections:	Diameter of Core (inches):
Water Depth/Elevation of Core:	Core Quality: ☐ Good ☐ Fair ☐ Poor ☐ Disturbed
Cored Length (feet; from log):	Average % Compaction =
Core Recovery (feet):	Internal Composite Received on:

Theoretical Depth in ( ) Actual Core Sections	Size % G	Size % S	Size % F	Summary Sketch	Classification and Remarks (Moisture content, density/consistency/ color, minor contituent, MAJOR constituent, amount, shape of minor constituent, sheen, odor)

SEDFLUME SAMPLING DATA SHEET

Sea Engineering, Inc.
Project Number: **Project Title:**

DATE (mm/dd/yy) ____________ INITIALS ________ AREA-STATION ID ______________

ON STATION (time) ____________ WATER DEPTH ________ Ft M Fm

STATION POSITION (NAD 83) Latitude or Northing ______________ Longitude or Easting ______________

SAMPLER USED (circle one) Vibracorer Gravity Corer Push Corer (size ______) Van Veen Grab Other:

Sampling Area	Sample Type	Minimum Acceptable Recovery
	Sedflume*	30 cm (1 ft)
* Core must have undisturbed surface and no visible fractures in core.		

Attempt Number					
Attempt Start/End Time	/	/	/	/	/
Apparent Penetration Depth (ft or cm)					
Recovery (ft or cm)					
Accepted (yes/no)					
Rejection Code					

Rejection Codes

OP	Overpenetrated	DB	Debris interference	NS	No sediment in sampler
NR	Insufficient Recovery	DS	Disturbed surface	FR	Core has visible fracture in sediments

For Acceptable Sample: Visible color change near surface? No Yes at ______cm Photographed ? No Yes	Attach Unique Sample ID here

Comments

Reviewed by ____________________ Date __________

SEDFLUME LABORATORY DATASHEET

Sample Designation: ____________________ Photo: __________

Date/Time: ____________________

Core Height: __________ cm

Reference Height for the top of the core: __________ cm

Reference Contact: ____________________

Location: ____________________

Project: ____________________

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (min, sec)	NOTES	

Bulk Density Datasheet

Sample Designation:

Date/Time:

Core Height: cm

Photo:

Location:

Project:

Reference Contact:

	Bulk Density Sample									
Sample ID	Depth	Tray Weight (g)	Wet Wt. (g)	Dry Wt. (g) 1 Date and Time	% water content	Dry Wt. (g) 2 Date and Time	% water content	Dry Wt. (g) 3 Date and Time	% water content	Bulk Density (g/cm3)

Particle Size Sample			
Tray Weight (g)	Dry Weight (g)	Beaker Weight (g)	Dry + Beaker (g)

ANCHOR ENVIRONMENTAL, L.L.C.

Chain of Custody Record & Laboratory Analysis Request

Anchor Environmental, L.L.C.
1423 3rd Avenue, Suite 300
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131

Turnaround Requested: **Anchor Contact:** **Page ___ of ____**

Lab Contact:	Project:	Analyses Requested
Lab:		
Address:	Proj. No.:	
City, etc: :	Sampler:	
Phone:	Shipping Method:	
Fax:	AirBill #:	

Sample ID	Sample Date	Sample Time	Sample Matrix	Number of Containers											Notes/ Comments:

Relinquished: (Signature)	Relinquished: (Signature)	Relinquished: (Signature)	Special Instructions/Notes	
Printed Name:	Printed Name:	Printed Name:		
Company:	Company:	Company:		
Date/Time:	Date/Time:	Date/Time:		
Received By:	Received By:	Received By:		
Printed Name:	Printed Name:	Printed Name:		
Company:	Company:	Company:	# of Coolers:	Cooler Temp(s):
Date/Time:	Date/Time:	Date/Time:	COC Seals Intact?	Bottles Intact?